NAVAL CONSULTING BOARD OF THE UNITED STATES

BY

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AND WAR COMMITTEE OF TECHNICAL SOCIETIES,
FROM INVENTIONS SECTION
GENERAL STAFF, U. S. A.

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The author desires to express his thanks and appreciation to the Chiefs of Bureaus of the Navy Department; to Rear Admiral William Strother Smith; to Mr. Thomas A. Edison, president of the Board; to Mr. William L. Saunders, chairman of the Board; to its secretary, Mr. Thomas Robins, and to the individual members of the Naval Consulting Board of the United States, as well as to its examiners and staff, including Mr. George W. Stretch, for their cooperation and assistance in helping him to get together the material for this book. The author assumes responsibility for statements made in this book.

JOSEPHUS DANIELS,

Secretary of the Navy.

SECRETARY DANIELS, ASSISTANT SECRETARY ROOSEVELT, THE NAVAL CONSULTING BOARD, AND NAVY DEPARTMENT REPRESENTATIVES.

PREFACE.

It would have been impossible for the Navy to have carried on its efficient part in winning the World War without the intelligent and patriotic contribution of civilian thinkers and workers as well as civilians who enlisted in every department of naval effort. Foremost among these civilian patriots stand the members of the Naval Consulting Board. Its members gave themselves fully to the service of their country, bringing scientific and engineering knowledge, with large experience touching the vital problems that confronted the Navy. The membership of this board was chosen by and from the foremost engineering societies in America, embracing men whose achievements were of world renown. The Navy, indeed the whole country, owes to their scientific patriotism a debt not only for what they wrought but quite as large a debt for the stimulus and inspiration they imparted to the naval personnel and to civilians enlisted in national service.

The Naval Consulting Board was not a war organization. It was called into being in 1915, long before America entered the World War, and it gave to naval problems study and research and investigation before the stress of war laid the imperative hand upon all Americans. During the war the individual members of the board, eminent and busy men whose services were in demand by the biggest concerns in the world, forgot their private business and individual pursuits and were as fully and wholeheartedly enlisted in the service of their country as any man who fought on land or sea. The president of the board, Mr. Thomas A. Edison, left his laboratory and practically became a naval officer, spending long months in the Navy Department and extended periods of deep-sea cruising that he might be in the closest touch with the problems to be solved. Other members of the board gave themselves and their talent as fully.

In appreciation of the work of the Navy Civilian Consulting Board for the Navy, the Council of National Defense requested the board to act as the Board of Inventions for the council, which was effective in mobilizing the industry and genius of the American people for war. Its work, therefore, burgeoned into the widest field of activity and accomplishment, leading in all the agencies and investigations and organizations of American skill and science in making American participation in the war worthy of the Republic.

The story of the organization and work of the board is interesting and illustrative of American resourcefulness and initiative and efficiency. Some of the things it did are told in this volume. Its spirit glows on every page. Some of its most important work must still be held confidential. When the time comes for the true perspective, the Naval Consulting Board will stand out as a pioneer and leading organization in the period in which science married to service gave new effectiveness to our new and better Americanism. To me the joy of comradeship and fellowship with the men of the Naval Consulting Board will ever be remembered as one of the pleasures and profits of experience in the World War.

JOSEPHUS DANIELS.

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CHAPTER I.

ORIGIN AND ORGANIZATION.

The creation of the Naval Consulting Board of the United States was a radical departure from the existing policies of the Navy Department.

In order to understand the motives which actuated the Secretary of the Navy, Josephus Daniels, in creating a board of 24 civilian inventors, engineers, and scientists and attaching it to his office, the position of the United States in world affairs in July, 1915, must be considered.

At that time the World War had been raging since August 1, 1914, on the Continent of Europe, with ever increasing violence. It seemed to many that the traditional policy of the United States of keeping aloof from European entanglements might at any time be terminated, as the ruthless policy of the German Empire and its disregard of the traditional rules of international law and conduct seemed to be drawing the United States nearer and nearer to the vortex of the conflict.

One affront to the United States by Germany succeeded another until finally the German Admiralty conceived the idea of blockading the British Isles by means of a submarine fleet.

On February 4, 1915, Germany issued a formal proclamation that the waters around Great Britain and Ireland were held to be a war zone, and that from February 18 "every enemy merchant ship found in this region will be destroyed without its always being possible to warn the crews or passengers of the dangers threatening. * * * Neutral ships will also incur danger in the war region, where, in view of the misuse of neutral flags ordered by the British Government, and incidents unavoidable in sea warfare, attacks intended for hostile ships may affect neutral ships also."

As it had long been the custom in warfare for the blockading vessel to first hold up and examine the suspected ship before taking any further action, and then if she was found to be an enemy ship to put a prize crew aboard and send her into port, this proclamation, which in effect was designed to destroy ships by the use of torpedoes launched from submarines without warning, violated an ancient and humanitarian custom as well as international law. Many citizens of the United States were traveling back and forth on ocean steamers between the United States and Europe on vessels flying the American flag and the flag of other nations, and it was seen that this proclamation, if carried out, would imperil their lives.

It was not long before, in the carrying out of this plan of blockade, that Germany commenced to sink merchant ships without warning. On March 9, 1915, three merchant ships were torpedoed without warning; on March 28, the Elder-Demster liner *Falaba*, on a voyage from Liverpool to South Africa, was stopped and torpedoed. As the crew and passengers sank, the Germans, looking on from the deck of the U-boat, laughed and jeered at their struggling victims, of whom 111 perished, among whom was one American.

The greatest insult to citizens of the United States was not committed, however, until April, 1915, when the German Embassy at Washington publicly advertised that passenger vessels like the *Lusitania* were liable to destruction, and that travelers sailing on them would do so at their own risk.

On May 1, 1915, the Cunard liner *Lusitania* sailed from New York for Liverpool, carrying, besides her crew of 651, no less than 1,255 passengers. Before she sailed it was widely rumored that the *Lusitania* would be sunk without warning, and many of the passengers received anonymous telegrams warning them that the ship would be sunk. No one, however, believed it would be possible for Germany to commit such a crime as to sink a vessel with 1,255 passengers without warning from the submarine and making provisions for safety of those on board, for, although Germany was known to be a ruthless antagonist, it was not conceived possible that she would take upon herself the responsibility of drowning the passengers, among whom were many Americans.

However, at 2.15 p. m. on Friday, May 7, 1915, the Germans torpedoed the *Lusitania* without warning, and at 2.36 she went down. Out of 1,906 souls on board, 1,134 went down with her and were drowned, including over 100 Americans.

Adding insult to injury, it was not long before reports came from Germany setting forth the attitude which the German people took in regard to this act. The press reports stated that the Germans seemed to revel in this crime, and that various celebrations were held in Germany on account of it. Medals were being struck to commemorate the sinking, and holidays were given to school children, and subscriptions taken up for the benefit of the crew of the U-boat which sank the *Lusitania*.

The Germans tried to justify this act on the ground that she carried munitions of war; but an inquiry held by Julius Meyers, judge of the United States District Court for the Southern District of New York, developed the fact that the *Lusitania* did not carry munitions. The following is an extract from the report:

> The evidence presented has disposed without question, and for all time, of any false claims brought forward to justify this inexpressibly cowardly attack on an unarmed passenger steamer.

On May 12, 1915, Woodrow Wilson, President of the United States, sent a note to the German Empire which clearly presented the situation that confronted the United States at that time. He said, in part:

> 1. The United States Government calls attention to the various incidents in the war zone proclaimed by Germany around the British Isles * * * the sinking of the British liner *Falaba* with the loss of Leon C. Thresher, an American; the attack by German airmen on the American steamer *Cushing;* the torpedoing without warning of the American steamer *Gulflight*, flying the Stars and Stripes; and finally the torpedoing without warning of the *Lusitania* with the loss of more than 1,000 lives of noncombatants, among them more than 100 Americans.
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> 2. These acts are claimed to be indefensible under international law. The United States points out that it never admitted Germany's right to do them and warned the Imperial Government that it would be held to strict accountability for attacks on American vessels or lives. A strict accounting, therefore, is now asked from Germany.
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> 3. The usual financial reparation will be sought, although Germany is reminded in effect that no reparation can restore the lives of those sacrificed in the sinking of the *Lusitania* and other ships.
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> 4. Expressions of regret may comply with legal precedents, but they are valueless unless accompanied by a cessation of the practices endangering lives of noncombatants.
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> 5. The right of neutrals to travel to any point of the high seas on neutral or belligerent merchantmen is asserted.
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> 6. In the name of humanity and international law, the United States demands a guaranty that these rights shall be respected, and that there be no repetition of attacks on merchantmen carrying noncombatants.
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> 9. In conclusion, Germany's attention is called to the earnestness of the Government and people of the United States in this situation. It is made plain that the United States will leave nothing undone, either by diplomatic representation or other action, to obtain compliance by Germany with the requests that are made.

Most Americans were impressed with the menace to the United States. Something had to be done to put America into a position where she could defend herself.

The press accounts gave daily news of the part that science and invention was playing in the war, of the introduction of new weapons, of the fact that those waging the war were utilizing the best inventive and scientific talent of their respective countries.

A progressive Secretary of the Navy, Josephus Daniels, realizing the great part that inventions and new devices were playing in the war, sought to find a method of helping to meet the situation. On July 7, 1915, he wrote a letter (see Appendix 286, p. 288) to Mr. Thomas A. Edison in which he complimented Mr. Edison on his attitude in refusing in these commercial times to devote his inventive genius to warlike purposes except at the call of his country, and said that he felt that his own ideas and Mr. Edison's coincided, if an interview with Mr. Edison, by Mr. Edward Marshall, published in the New York Times, was correct.

He stated that he felt that one of the important needs of the Navy was machinery and facilities for utilizing the natural inventive genius of Americans to meet the new conditions of warfare as shown abroad, and that he intended to establish at the earliest possible moment a department of invention and development to which all ideas and suggestions from either the service or civilian inventors could be referred to determination as to whether they contain practical suggestions for the Navy to take up and perfect.

He said that the Navy had no present means of handling inventions received from the public except by sending them to the various bureaus of the Navy, which were overcrowded with routine work, and that in the circumstances under which they had to be handled an idea having the germ of an improvement could not always be given the attention it deserved. He felt that naval officers on sea duty were in a position to note improvements, but that they had neither the time nor special training nor in many cases the natural inventive mind needed to put these ideas into definite shape.

He stated that there was no particular place or particular body of men relieved of other work and charged solely with their devising new things themselves or perfecting the crude ideas that were submitted to the department by the naturally inventive people of the United States, and that he had in mind a general plan of organizing a department for the Navy which met with the ideas of Mr. Edison, as set forth in the interview, for such a department for the Government in general.

Mr. Daniels thought that such a department would have to eventually be supported by Congress with sufficient appropriations, but that they had the means at hand to make a start.

He therefore asked Mr. Edison if he would be willing, as a service to his country, to act as adviser to such a board, and that with Mr. Edison's knowledge, combined with the practical knowledge of the officers of the Navy, and a department composed of the keenest and most inventive minds that could be gathered together, the Nation would be able to meet the submarine danger with new devices that would assure peace to our country by their effectiveness.

He said that it was on Mr. Edison's aid that he relied mostly, and if he was not able, for any reason, to do this, that he would hesitate to undertake the matter at all.

On July 13, 1915, Dr. Miller Reese Hutchison, chief engineer to and personal representative of Mr. Edison, at the request of the latter visited Secretary Daniels in Washington, and advised him that Mr. Edison had consented to head such a board as Secretary Daniels had outlined in his letter of July 7, 1915.

Thereafter Secretary Daniels and his aid visited Mr. Edison at Orange, N. J., and they conferred at his residence on the salient features of the board.

Secretary Daniels then wrote to the presidents of the 11 largest engineering societies in the United States and asked each, as president of the organization, to secure the selection of two of its members to serve on this Naval Advisory Board, further stating "The judgment of your members as to who is most qualified among you to serve on this board will be far better than my own."

This action on the part of the Secretary of the Navy of placing the responsibility for the selection of the members of the Naval Advisory Board upon the engineering societies insured that its membership would be nonpartisan in character.

The name "Naval Advisory Board" was used in the earlier communications, but at its organization meeting the name "Naval Consulting Board of the United States" was adopted as the official title for the organization.

The step taken by the Secretary of the Navy in creating the Naval Consulting Board was, in effect, the first step taken by any Government official toward preparing the country for war and, in the organization of the board in the manner above set forth, the Secretary of the Navy incorporated in its organization not only inventors but also engineers who had dealt with constructive problems and who were the heads of large industrial organizations. This placed in the public eye and in a place of great responsibility some 24 men, leaders in the inventive, engineering, and industrial world, who were closely in touch with public opinion of the country and the attitude of the American people toward preparedness.

This resulted, as is set forth in a later chapter, in a great campaign for industrial preparedness, which was one of the first things of a constructive nature which the board inaugurated.

The names of the societies selecting the members of the Naval Consulting Board, the members selected, and the method used to select them were as follows:

Thomas A. Edison; selected by the Secretary of the Navy.

Dr. M. R. Hutchison; selected by the Secretary of the Navy.

American Chemical Society: Dr. L. H. Baekeland and Dr. W. R. Whitney; selected by letter ballot council of some 150 members.

American Institute of Electrical Engineers: Frank J. Sprague and B. G. Lamme; selected by the board of directors of the American Institute of Electrical Engineers, after first obtaining suggestions from a large group of representative members consisting of the past presidents, members of the board of directors, and the chairmen of the branch organizations located in the principal cities of the country.

American Mathematical Society: R. S. Woodward and Arthur G. Webster; selected by the president of the American Mathematical Society under the general power of his office to appoint delegates.

American Society of Civil Engineers: A. M. Hunt and Alfred Craven; selected by the board of directors of the society.

American Aeronautical Society: M. B. Sellers[1] and Hudson Maxim; these men were selected by canvassing the membership of the society and the board of directors at a special meeting convened for that purpose, being guided by the recommendation of the members at large.

Inventors' Guild: Thomas Robins and Peter Cooper Hewitt;[2] selected by a mail ballot of the entire membership of the society.

American Society of Automotive Engineers: Howard E. Coffin and Andrew L. Riker; selected by letter ballot of the voting members of the society.

American Institute of Mining Engineers: William L. Saunders and Benjamin B. Thayer; selected by ballot at a meeting of the board of directors.

American Electrochemical Society: Lawrence Addicks and Prof. Jos. W. Richards;[2] selected by the board of directors.

American Society of Mechanical Engineers: W. L. R. Emmet and Spencer Miller; selected by the council by letter-ballot. The executive committee selected a list of members, which was sent out to all the council members with the request that each man nominate at least six names, which need not, however, be confined to the list sent out. This preliminary ballot was followed by a second ballot, of which only two names were requested to be balloted for. The result was that the council then made the appointment of the two names which received the highest votes.

American Society of Aeronautic Engineers: Elmer A. Sperry and Henry A. Wise Wood;[3] selected by ballot of the members and associates of the society.

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[1] Resigned Mar. 6, 1918.
[2] Resigned Nov. 2, 1918.
[3] Resigned Dec. 24, 1915; succeeded by Bion J. Arnold.

War Committee of Technical Societies: D. W. Brunton; as chairman of the war committee, appointed to the board after its formation by the Secretary of the Navy.

On October 7, 1915, the organization meeting of the Naval Consulting Board was held at the Navy Department, Washington, D. C. The following members of the board were present:

Thomas A. Edison (chairman), Lawrence Addicks, Dr. L. H. Baekeland, Howard E. Coffin, Alfred Craven, William Le Roy Emmet, Dr. Peter Cooper Hewitt, Andrew Murray Hunt, B. G. Lamme, Hudson Maxim, Spencer Miller, Prof. Jos. W. Richards, Andrew L. Riker, Thomas Robins, W. L. Saunders, Matthew Bacon Sellers, Elmer A. Sperry, Frank J. Sprague, Benjamin B. Thayer, Dr. Arthur G. Webster, Dr. W. R. Whitney, Henry A. Wise Wood, Dr. Robert S. Woodward.

At this meeting of the board the following rules were adopted:

1. The officers of this board shall be a chairman, a first vice chairman, a second vice chairman, and a secretary, and shall be chosen from the members of the board.

2. Regular meetings of the board shall be held at intervals of two months and special meetings shall be called by the secretary of the board with at least seven days' notice, upon the request of the Secretary of the Navy, the chairman, a vice chairman, or any five members of the board, the time and place of the meeting to be arranged by the secretary of the board in conference with two of the chairmen.

3. At any meeting in the absence of the chairman and first and second vice chairmen, any member present may be chosen as chairman pro tempore by a majority of those present. A quorum shall consist of 10 members.

4. Members absent from a meeting may record a vote by mail or telegram, to be cast by the secretary, when a vote is taken on any matter which has been named for action or discussion in the call for the meeting. No vote by proxy shall be recorded.

5. The proceedings and discussions of this board shall be recorded by the secretary and part or all of them may be made public only by him with the concurrence of the presiding officer and the approval of the Secretary of the Navy.

6. All matters submitted to the board by the Secretary of the Navy shall be communicated to all the members by the secretary of the board, who will forward the replies to the appropriate committees, to be collated by them and presented to the members of the board with recommendations for their assent or dissent.

7. The second vice chairman shall appoint a committee of three members to act with him in the selection of the members of the following subcommittees: (1) Chemistry and physics; (2) aeronautics, including aero motors; (3) internal-combustion motors; (4) electricity; (5) mines and torpedoes; (6) submarines; (7) ordnance and explosives; (8) wireless and communications; (9) transportation; (10) production, manufacture, and standardization; (11) ship construction; (12) steam engineering and ship propulsion; (13) life-saving appliances; (14) aids to navigation; (15) food and sanitation.

8. Power shall be lodged in the chairman to appoint such additional committees as he may find necessary. These subcommittees are to consist of such

a number as, in the opinion of the chairman of the subcommittee, may seem desirable.

After the first meeting of the board on October 6, 1915, in the office of the Secretary of the Navy the board was received by President Wilson in the White House.

He thanked the board for volunteering to give its services to the country in the present seeming emergency and stated that it was the first act of preparedness against that which he was afraid could not be avoided. He said that not only should we be prepared to meet the emergency of war, but adequately prepared. He remarked on the high character of the personnel of the board and complimented Secretary of the Navy Daniels in putting the movement to mobilize the inventive talent of the country into effect.

At a meeting of the board held on November 4, 1915, at India House, New York, the board came to the conclusion that its work could best be carried on through the organization of committees, each committee to deal with its own particular subject. The members indicated on which, of a list of committees on various scientific subjects, they felt best qualified to serve. They thus became members of these committees. As a result the following committees were created, and they initiated and dealt with all matters coming before the board that were within the purview of the committee:

Chemistry and Physics.—Chairman, W. R. Whitney; L. Addicks, L. H. Baekeland, J. W. Richards, M. B. Sellers, A. G. Webster, R. S. Woodward.

Aeronautics, including Aero Motors.—Chairman, Henry A. Wise Wood; H. E. Coffin, P. C. Hewitt, A. L. Riker, M. B. Sellers, E. A. Sperry, A. G. Webster.

Internal Combustion Motors.—Chairman, A. L. Riker; H. E. Coffin, M. B. Sellers, E. A. Sperry.

Electricity.—Chairman, Frank J. Sprague; L. Addicks, W. L. R. Emmet, P. C. Hewitt, B. G. Lamme, A. G. Webster.

Mines and Torpedoes.—Chairman, Elmer A. Sperry; L. H. Baekeland, M. R. Hutchison, Hudson Maxim.

Submarines.—Chairman, W. L. R. Emmet; A. M. Hunt, M. R. Hutchison, W. L. Saunders, F. J. Sprague.

Ordnance and Explosives.—Chairman, Hudson Maxim; L. H. Baekeland, A. M. Hunt, M. R. Hutchison, F. J. Sprague, A. G. Webster, W. R. Whitney, H. A. W. Wood, R. S. Woodward

Wireless and Communications.—Chairman, P. C. Hewitt; A. G. Webster, W. R. Whitney.

Transportation.—Chairman, B. B. Thayer; H. E. Coffin, A. Craven, S. Miller, A. L. Riker, T. Robins, W. L. Saunders.

Production, Organization, Manufacture, and Standardization.—Chairman, H. E. Coffin; L. Addicks, W. L. R. Emmet, B. G. Lamme, T. Robins, W. L. Saunders, B. B. Thayer.

Ship Construction—Chairman, F. J. Sprague; S. Miller, J. W. Richards, H. A. W. Wood.

Steam Engineering and Ship Propulsion.—Chairman, A. M. Hunt; W. L. R. Emmet, B. G. Lamme, J. W. Richards, M. B. Sellers.

Live-Saving Appliances.—Chairman, S. Miller; Hudson Maxim, T. Robins.

Aids to Navigation.—Chairman, Elmer A. Sperry; A. Craven, A. M. Hunt, H. A. W. Wood, R. S. Woodward.

Food and Sanitation.—Chairman, L. H. Baekeland; H. Maxim, B. B. Thayer, W. R. Whitney, R. S. Woodward.

Public Works, Yards and Docks.—Chairman, A. Craven; L. Addicks, A. M. Hunt, S. Miller, J. W. Richards.

The Committee on Chemistry and Physics was later divided as follows into two committees:

Chemistry.—W. R. Whitney, chairman; L. Addicks, L. H. Baekeland, A. G. Webster, R. S. Woodward.

Physics.—A. G. Webster, chairman; L. Addicks, L. H. Baekeland, W. R. Whitney, R. S. Woodward.

Committees added later were:

Fuel and Fuel Handling.—S. Miller, chairman; L. Addicks, L. H. Baekeland, A. M. Hunt, M. R. Hutchison, Hudson Maxim, T. Robins, B. B. Thayer, A. G. Webster, W. R. Whitney.

Metallurgy.—Chairman, J. W. Richards (resigned); L. Addicks (made chairman on resignation of Richards), B. G. Lamme, B. B. Thayer, W. R. Whitney.

Optical glass.—Chairman, L. H. Baekeland; A. G. Webster, W. R. Whitney.

Special Problems.—Chairman, B. G. Lamme; L. Addicks, A. M. Hunt, M. R. Hutchison, E. A. Sperry, F. J. Sprague, A. G. Webster, W. R. Whitney.

In its early organization no definite responsibility was placed upon any member of the board. Although the rules as adopted at the first meeting stated that there should be a chairman, first vice chairman, second vice chairman, and a secretary, no specific duties were given to the holders of these offices except such as would ordinarily come within their purview.

The subjects which were taken up by the board therefore did not necessarily originate with its officers and in most cases originated with individual members and committees.

It was understood between Mr. Edison and Secretary Daniels when he took the presidency of the board that it was his inventive talent that was wanted and not his administrative and executive ability.

Mr. Edison had been asked to be advisor to the board and, although he was elected its first chairman, he did not act as the executive officer of the board in the sense usually understood in the business world, where the executive takes responsibility for the policies and the work of an organization.

The organization structure evolved by the Naval Consulting Board was one in which the first vice chairman, Mr. W. L. Saunders, acted as presiding officer at meetings and coordinated the efforts of the members, and there devolved upon the secretary of the board, Mr. Thomas Robins, the duty of becoming the clearing house for all communications between the board and the Navy Department and assisted the vice chairman in coordinating the efforts of the individual members of the board. Later Mr. Thomas Edison became president of the board and Mr. William L. Saunders its chairman. Although the titles changed their functions remained as above.

The members of the board not only serve without compensation but for some time paid their own traveling expenses, so that their efforts on behalf of the Government were purely voluntary and gratuitious and rendered out of a spirit of patriotism. After the board was legalized, however, traveling expenses of the members in discharge of their duties were paid by the Government.

In order to understand the subsequent history of the Naval Consulting Board it is necessary to consider the organization with which it had become associated, viz. the Navy Department. This department, represented by the Secretary of the Navy in the Cabinet of the President of the United States, is a highly developed branch of the Government in which duties and responsibilities are definitely placed on the officers and men of the department, and which is a complete organization in itself.

As heretofore stated in Secretary Daniels's letter to Mr. Edison, he desired to create a new department for the Navy for the purpose of handling inventions, and on account of the fact that all the bureaus of the Navy were loaded down with routine work.

As the duties and responsibilities of the bureau chiefs and officers of the Navy are set forth by congressional act, the fitting of this board into the Navy Department was not an easy matter. It could not be given any definite legal status in the beginning, as that could only come about through congressional enactment, so that the first few months of its activities, and before it became legalized by Congress in 1916, it was, in the strict sense of the word, not a part of the Navy Department, and, therefore, the bureau chiefs and officers of the Navy, on whom great responsibilities rested for the operation and maintenance of the Naval Establishment, had some difficulty in knowing just what position they should take in order to help forward the work of the Naval Consulting Board.

The work of the Navy Department is carried on by a system of bureaus: at the head of each bureau is a bureau chief on whom devolves responsibility of administering the work of that bureau much in the same way as the president of an underlying corporation in the commercial world administrates affairs for the benefit of a holding company. In carrying out this comparison, the holding company would be represented by the office of the Secretary of the Navy.

The Secretary of the Navy receives his appointment from the President of the United States, who is Commander in Chief of the Navy, so that the source of his power is from the Commander in

Chief rather than by congressional legislation. The Congressional Directory for 1919 defines the official duties of the Secretary of the Navy as follows:

The Secretary of the Navy performs such duties as the President of the United States, who is Commander in Chief, may assign him, and has the general superintendence of construction, manning, armament, equipment, and employments of vessels of war.

The officer in the Navy Department charged with the largest powers and importance is the Chief of Naval Operations.

The Chief of Naval Operations, under the direction of the Secretary of the Navy, is charged with the operations of the fleet and with the preparation and readiness of plans for its use in war.

The following is a sketch of the most important duties of the various bureaus and officers of the Navy, as set forth in congressional enactment:

The Bureau of Navigation issues, records, and enforces the orders of the Secretary to the individual officers of the Navy.

The Bureau of Yards and Docks designs and constructs the public works, such as dry docks, marine railways, building ways, etc.

The Bureau of Ordnance has charge of the upkeep, repair, and operation of the torpedo station, naval proving grounds, and magazines on shore and the manufacture of offensive and defensive arms and apparatus, including torpedoes and armor, all ammunition and war explosives, etc.

The Bureau of Construction and Repair is responsible for the structural strength and stability of all ships built for the Navy; all that relates to designing, building, fitting, and repairing the hulls of ships; turrets, electric turret-turning machinery, etc. It also has charge of the docking of ships, and is charged with the operating and cleaning of dry docks.

The Bureau of Steam Engineering is in charge of all that relates to the designing, building, fitting out, and repairing machinery used for the propulsion of naval vessels. It inspects all fuel for the fleet, and is specifically charged with the design, supply, installation, maintenance, and repair of all means of interior and exterior electric signal communications, including the repair and operation of radio outfits on shipboard and on shore. It also takes charge of the design, manufacture, installation, maintenance, repair, and operation of aeroplane motors and propellers and their attachments.

The Bureau of Medicine and Surgery has charge of the upkeep and operation of all hospitals and of the force employed there, etc.

The Bureau of Supplies and Accounts has charge of all that relates to the purchase, reception, storage, care, custody, transfer, shipment, and issue of all supplies for the Naval Establishment and the keeping of property accounts for the same; the procuring of provisions, clothing, and small stores and material under the naval supply account.

The Paymaster General of the Navy, who is the Chief of the Bureau of Supplies and Accounts, has supervision over the loading and cargoes of supply ships, and he is responsible for the purchase of all supplies for the Naval Establishment, including provisions and clothing and the preparation of contracts and bureau orders in connection with purchases.

The naval supply account is administered by the Paymaster General of the Navy, and governs the charging, crediting, receipt, purchase, transfer, manufacture, repair, issue, and consumption of all stores for the Naval Establishment, except for a few items which are specifically exempted.

Naval clothing factories are also under the control of the Paymaster General of the Navy. He has supervision over all that relates to the supply of funds for the disbursing officers, the payment for articles and services for which contract and agreement have been made, and the keeping of the money accounts of the Naval Establishment.

The duties of the Judge Advocate General of the Navy are as follows: To revise and report on the legal features of and to have recorded proceedings of all courts-martial, courts of inquiry, boards of investigation, etc.

The duties of the Solicitor relate to the examination and report upon questions of law, including the drafting and interpretation of statutes.

All the duties of the bureaus are performed under the authority of the Secretary of the Navy, and their orders are considered as emanating from him and have full force and effect as such.

The chiefs of bureaus issue orders concerning the work of their own bureaus, provided such work is not of a character to alter the military characteristics of any ship. Any proposed work the performance of which would alter the military characteristics of any ship is referred to the Secretary of the Navy for decision prior to authorization.

Each bureau determines on and requires for or has manufactured all material, apparatus, tools, stores, fuel, transportation, etc., needed for its own use in carrying out its duties. It is charged with all that relates to the equipments of ships, according to its allowance, and estimates for and defrays from its own funds the cost necessary to carry out its duties as hereinafter defined.[1]

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[1] Functions of the various bureaus, as provided by sec. 624 of the Revised Statutes of the United States, as amended by act of Mar. 3, 1899, sec. 13, and by the acts of May 13, 1908, Feb. 16, 1909, and Aug. 22, 1912, ch. 2, sec. 1, par. 2.

When a conference becomes necessary to facilitate the transaction of business affecting the interest of any bureau or office, the chief of such bureau or head of such office, when notified by the appropriate head, designates a representative to attend to such conference.

In every case pertaining to the design, alteration, or repair of ships or equipage, wherein any bureau recommends for approval any departure from the recognized standard practice, or any case in variance with any former decision of the department, the bureau invites the attention of the department to (*a*) the provision, decisions, or rulings of the department in regard to the subject in question, and (*b*) the reasons for recommending any departure from existing practice or change in policy.

The General Board is composed of the Chief of Naval Operations, Director of Naval Intelligence, President of the Naval War College, the Major General Commandant of the Marine Corps, and such additional officers as the Secretary may designate. Any officer above the grade of lieutenant is detailed as secretary of the General Board.

The General Board devises measures and plans for the preparation and maintenance of the fleet for war, etc., and prepares and submits to the Secretary of the Navy plans of strategy, including co-operation with the Army, and considers the number and types of ships proper to constitute the fleet. It also advises the Secretary concerning the location, upkeep, and protection of fuel depots. It co-ordinates the work of the Naval War College and the Office of Naval Intelligence.

The President may select any officer not below the grade of commander on the active list of the Navy and assign him to the command of a squadron with the rank and title of flag officer.

Not only are the duties of the naval officers in the different bureaus definitely prescribed, as above set forth, but in the early part of each year each bureau is required to make an estimate of its prospective expenditures for the fiscal year commencing July 1. A bill founded on this budget is then enacted in Congress and appropriations made for the upkeep of the Naval Establishment. The bill, as enacted, specifies the items for which the money is to be expended, even down to prescribing the number of scrubwomen and the rate at which they are to be paid.

The specific amounts for experimentation and research allowed by Congress are very meager. The result of this system for the maintenance and operation of the Naval Establishment is that the whole organization is set forth in congressional enactments and appropriations are specifically made by Congress for specific purposes. Money is provided for the carrying out of the duties above set forth, so that at the beginning of any fiscal year each bureau and office concerned with material knows what its duties are, which are prescribed by Congress, and how much money and material it is going to have to carry them out.

Each bureau has facilities for doing work in its own line, but if it attempts to do anything in regard to research or development work, special facilities have to be arranged for that purpose. Men have to be taken off the active routine work upon which they are engaged and special space has to be set aside for the particular thing to be investigated.

If a big Diesel engine were to be built by the Navy Department, it practically would have to know if the Diesel engine would work before they had it made; and it is quite unlikely that Congress would make an appropriation to build an experimental engine which would have to be scrapped and another one built before it was sufficiently developed to warrant incorporating it in the equipment of a naval vessel.

Congress having made appropriations for each bureau, the expenditures in said bureaus are made by the chief of the bureau who allots amounts to be allowed for various purposes. The Bureau of Supplies and Accounts draws amounts from the Treasury of the United States and pays bills in accordance with allotments made by the chief of the bureau.

The personnel of the Navy is paid directly by the Bureau of Supplies and Accounts, which draws checks or drafts on the Secretary of the Treasury.

Frequently money is needed from the appropriations made to more than one bureau, as, for instance, in the case of an engineering officer engaged on work in one of the navy yards which involves two bureaus. He would be obliged to make an estimate of the requirement from the Bureau of Steam Engineering and the Bureau of Construction and Repair, for instance. The commandant of the yard would then be obliged to make requisition on the various bureau chiefs for these amounts. The bureau chiefs would O. K. these requisitions and return them to the commandant of the yard, and the commandant of the yard would then file them with the Treasurer of the United States and draw the necessary money, which would then be placed in the control of the paymaster of the yard. The funds, once in the hands of the paymaster of the yard, could be drawn on by the officer who is expending the money for the purchases for which he made the requisitions.

The method required to install new devices on shipboard is as follows: If the Bureau of Ordnance decided to install a certain device on shipboard, which incorporated in its mechanism certain electrical attachments, which happened to be under the control of the Bureau of Construction and Repair, the Bureau of Ordnance would be obliged to have a conference with the Bureau of Construction and

Repair in regard to the matter of the installation, and in the event of a dispute as to the advisability of installing the device the matter would have to be referred to the Secretary of the Navy, who would, no doubt, select some one from the General Board of the Navy to report to him on the merits of the device.

It can thus be seen that the rigid organization of the Navy in regard to the prescription of duties of the various men attached to bureaus, the inflexible budget system, by which appropriations are made for specific things for one year in advance, the division of responsibility among several bureaus in regard to the installation of any new device, makes for conservatism in the installation of such new devices.

By regulation of Navy Department it is provided that where any bureau recommends for approval any departure from recognized standard practice or any case in variance with any former decision of the department, such bureau shall invite the attention of the department (*a*) to the provision, decisions or rulings of the department in regard to the subject in question and (*b*) the reasons for recommending any departure from existing practice or change in policy.

Great responsibility is placed by congressional action upon the bureau chiefs, who are selected for a term of four years by the Secretary of the Navy, the nominations are approved by the President of the United States and sent to the Senate for confirmation. The four-year terms of the bureau chiefs do not necessarily coincide with the four-year term of the Secretary of the Navy. Some Secretaries of the Navy have been known in the past to ask for the resignation of a bureau chief, as soon as the bureau chief was appointed, in order that they might have control.

In the event that the Secretary of the Navy directs a change in the material or design of naval equipment, he relieves the bureau or bureau chiefs of all responsibility in regard to it. These men and their suporting organization having the authority and responsibility, and being actively engaged in this work, know more about it than the Secretary of the Navy. He is therefore necessarily very reluctant to take responsibility for changes from the shoulders of those on whom it rests. His reasons for doing so must be extremely good reasons.

Not only did changes in material matters of the Navy involve many interests, but this also applies to any change in the organization of the Navy Department, such as the introduction of another body such as the Naval Consulting Board. And disturbance of the existing system for the administration of the Navy, involved matters of far-reaching importance. The Navy Department is so organized that each officer is vested with well-defined and clear-cut duties and responsibilities.

From the above outline of the duties and responsibilities which are placed upon the bureaus of the Navy Department by congressional enactment, it can be readily seen, when the Secretary of the Navy decided to take a radical and progressive step toward preparing the country for war by the mobilization of the inventive, scientific, and engineering talent of the country, he had a rather unique problem to solve.

The functions of the bureaus, being so definitely set forth by congressional enactment, and making a rigid structure, he could not create a new bureau for the Navy Department without special congressional legislation. He could not well make hard and fast rules for cooperative work between the Naval Consulting Board and the bureaus of the Navy, as the Naval Consulting Board, as formed by himself, had no definite governmental status and was not a legalized bureau or department.

He, therefore, did the only thing possible and that was to attach the Naval Consulting Board to the office of the Secretary of the Navy in an advisory capacity and use his influence and the prestige of his office to bring about a cooperation between the bureaus of the Navy and the inventive, scientific, and engineering talent as represented on and by the Naval Consulting Board.

The Naval Consulting Board, therefore, was obliged to find itself and work out its own destiny, with the cooperation of the Secretary, as best it could, with a rather rigid and firmly established Naval Establishment on the one hand and a public which was trying to express itself through some Government medium to prepare the country for war and mobilize the inventive talent of the country for that purpose.

Until the Naval Consulting Board was made a focal point for the concentration of the inventive talent of the country for naval use, no one knew, before a record of its experience was made, what inventions the country could produce for war purposes. The experience of the board showed that inventions are not created by the waving of a wand, so to speak, but are predicated upon the application of highly technical knowledge and information to the solution of naval problems, which must be exhaustively considered. All of the facts in relation to each problem must be collected, and an attack made upon it by thoroughly equipped scientists of an inventive type. It was shown that this can best be done by groups of specialists, each one contributing an increment of knowledge to the solution of the problem. This group work develops new knowledge based on the composite knowledge contributed by members of the group. This new knowledge comes about through observation and experience, and frequently accidental discoveries are made of new phenomena which, when finally incorporated into a device, make for its success.

The Special Problems Committee of the Naval Consulting Board, mentioned hereafter, made its attack on the submarine problem in this way, and substantial results were achieved.

At the first meetings of the board, on the invitation of the Secretary, many of the bureau chiefs attended. At one of the early meetings of the Naval Consulting Board it was suggested that a representative of the Navy Department be made a member of each subcommittee of the board. The bureau chiefs, however, who were present at this meeting, stated that they thought this would create the impression that the Naval Consulting Board was a side issue of the Navy Department and being run by the department, if the officers of the Navy were definitely associated in the membership of these committees, and that they thought it would be best for the Naval Consulting Board to retain its organization absolutely independent of the Navy Department. This proposal to have representatives of the Navy Department on the subcommittees of the Naval Consulting Board was made before the Naval Consulting Board had any official standing, it having been legalized about a year later, and the action of the bureau chiefs was no doubt founded upon their intimate knowledge of the complex organization of the Navy Department and the unofficial status of the Naval Consulting Board.

It was finally decided that the proper method of liaison between the Navy Department and the Naval Consulting Board was to have an officer of high rank attached to the office of the Secretary of Navy and detailed for work with the board. This plan was carried out and Rear Admiral William Strother Smith was appointed to duty with the Naval Consulting Board, in order that he might keep the board informed of anything of importance that came up in the Navy Department to which their attention should be directed and to coordinate its activities.

In those early days the organization of the board and prior to its having been legalized, the public was sending in ideas and suggestions for new inventions to the Navy Department, and this resulted in the creation of an "Inventions Office" attached to the office of the Secretary of the Navy, through which all inventions which were recommended by the Naval Consulting Board or its committees passed. Admiral Smith was in charge of this office.

From October 7, 1915, until August 29, 1916, the Naval Consulting Board was an unofficial body, but by act of Congress, known as "An act making appropriations for the naval service for the fiscal year ending June 30, 1917, and for other purposes, approved August 29, 1916," Congress legalized this board in what was thought to be the best way. On page 3, the act reads: "For actual expenses incurred by and in connection with the Civilian Naval Consulting Board, $25,000." This, in the opinion of lawyers, fully legalized the board and thereafter its legal status was such as to allow it to undertake duties it had not performed before.

Immediately after it was legalized, an organization meeting took place in the office of the Secretary of the Navy on the 19th day of September, 1916. After hearing an address by the Secretary and taking the oath of allegiance,[1] the party left the Navy Department at 4.30 for the navy yard, boarding the U. S. S. *Dolphin.*

Secretary Daniels, accompanied by Admiral Benson, Capt. William Strother Smith, and Lieut. Commander Byron McCandless, received the board on shipboard and the party left for Old Point soon thereafter, arriving on the morning of the 20th, where they proceeded to Lynnhaven Bay and boarded the U. S. S. *Texas.*

On board the *Texas*, the Secretary was received by Admiral Mayo, Vice Admiral Coffman, Rear Admiral Fechteler, and their respective staffs. The *Texas* got underway and proceeded out to the Southern Drill Grounds, where they witnessed target practice by the fleet and also firing from the *Texas.*

A seaplane was launched from the U. S. S. *North Carolina* and executed maneuvers in rather rough water.

Admiral Mayo, assisted by Capt. Blue, commanding the *Texas*, entertained the party at luncheon.

In the afternoon the party returned to the *Dolphin* in Lynnhaven Bay and arrived in Washington the following morning.

By resolution, the officers who had served the temporary organization were made officers of the new organization, and the committees as established by the temporary organization were declared to be the regular committees of the new board, and a committee of three was appointed by the chairman to draft by-laws for the permanent organization, and the following rules and regulations for the continuance and government of the Naval Consulting Board, subject to the approval of the Secretary of the Navy, were adopted:[2]

Into this environment came the 24 men of the Naval Consulting Board from the civilian activities which had engrossed them up to the time of their appointment. They were all men of strong personalities, successful in their individual activities, mature in their judgment, and the subsequent history of the board is largely the reaction of these men as individuals to the environment in which they found themselves. As pointed out above, they dealt with a rigidly organized Navy Department in the beginning without any official

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[1] See Appendix, p. 251. [2] See Appendix, p. 248.

status on their part. Their activities reflected a responsiveness to current thought in regard to preparing of the United States for war, and their unique position enabled them to set in motion forces which later were of the utmost importance in bringing about the mobilizing of the country for war.

As a result, within a few weeks after its organization an inventory was taken of the industrial resources of the United States. The method evolved for taking this inventory by the use of the engineers of the country without doubt resulted in determining the character of the Government structures for carrying on the war.

The well-organized publicity campaign which accompanied the taking of the inventory no doubt aroused the people to a point where they were ready to go to war when it was declared April 6, 1917.

CHAPTER II.

THE INDUSTRIAL PREPAREDNESS CAMPAIGN.

In order to understand the industrial preparedness campaign of the Naval Consulting Board one must go back to the work of one of its members, Mr. Howard E. Coffin, in the standardization of materials in the motor-car industry.

The motor-car industry in 1909 was in such a position that it was almost impossible to obtain even the simplest kind of material for the construction of motor cars. This situation had been brought about because of a lack of standardization, either in specifications, designs, or materials in the industry. The committee formed to investigate this situation found it a very amazing one. The output of motor cars and the growth of the industry were being restricted because of inability to purchase materials, and an analysis of these difficulties lead to the discovery that nearly all of them could be traced to the fact that every concern in the country, and in many instances different departments of the same concern, were ordering for identical purposes widely different materials. For instance, in the case of the Shelby Tube Co., it was found that they were asked to draw for the motor-car industry alone somewhere in the neighborhood of 1,700 different specifications for tubing. The steel industry was being called on for special brands of steel and for special analysis of steel almost as varied as there were engineers in the industry, and even in such minor items as lock washers, we found that the Standard Lock Washer Co. was being asked to supply to the motor-car industry over 800 different specifications for lock washers between the sizes of five-sixteenths and five-eighths.

Each tire manufacturer insisted upon his peculiar form of rim and mold for the bending of his tire, with the result that no two sizes of tires produced by different manufacturers would fit the same rim. The results of this multiplicity of specification were twofold, both tending to work disaster to the growth of any industry. (1) Since each manufacturing concern was ordering special material through its engineering department, its purchasing department would have to await delivery under these special specifications until such time as the material could be manufactured; the orders, of course, taking precedence, in accordance with the time of being placed. (2) The producer of raw materials or of the commodities entering into motor-car construction were unable to manufacture in quantities or in advance of the actual needs, as evidenced by the orders upon their books, because there was no assurance that even the same concern would ever again place an order for the particular specifications which it had once ordered.

Mr. Coffin, in January, 1910, was elected president of the Society of Automobile Engineers, which was later succeeded by the Society of Automotive Engineers, and, with the cooperation of others, put the society upon a new footing by organizing it on a business basis for the purpose of bringing about standardization of specifications and materials used in the motor-car industry. A general committee of 125 men was divided into a large number of subcommittees, each dealing with some specific phase of the subject. The results of the work of this organization gave the motor-car industry a technical literature which has made possible its present growth to easily the third place in the scale of the business activities of the United States, and every draftsman and engineer in the industry now has on his desk a technical guide—in short, a Kent of the Motor Car Field—standards of design, specification, and material are at his hand, and purchasing departments are able to purchase and obtain quick delivery upon materials and parts necessary for motor-vehicle construction.

The plan of organization of the Naval Consulting Board into subcommittees followed somewhat the same scheme used by the Society of Automotive Engineers in their work of standardization; and, on account of his prior experience in this field, Mr. Coffin was made chairman of the Committee on Production, Organization, Manufacture, and Standardization of the Naval Consulting Board on or about November 8, 1915, the other members of the committee being William L. Saunders, Lawrence Addicks, William Le Roy Emmet, Thomas Robins, Benjamin G. Lamme, and Benjamin B. Thayer.

Upon being notified of his election as chairman of this committee, Mr. Coffin's reaction to the notification was immediate, and with his experience in connection with the standardization of materials and specifications for the motor-car industry, he set in motion an investigation to find out from the War and Navy Departments what data they had in their files pertaining to production capacities of the industrial plants of the country which were likely to be called upon for the production of war materials in the event of war. It was found that the information was very meager and in no way adequate to meet the needs of the country in the event of hostilities.

In December, 1915, a meeting of the Committee on Production, Organization, Manufacture, and Standardization was called in the office of the secretary of the board, Mr. Thomas Robins. The name of this committee was later shortened to that of "Industrial Preparedness." At this meeting ways and means for the accomplishment of an industrial inventory of the country were discussed, and as a result of the deliberations of this committee it was decided to call together the presidents of the following five engineering organizations—American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, and American Chemical Society.

We feel it is safe to say that the industrial preparedness campaign was founded upon the experience of Mr. Howard E. Coffin with the standardization of the specifications and materials in the motor-car industry and his particular reaction to his environment when placed by the Society of Automotive Engineers and the Secretary of the Navy in the position of a member of the Naval Consulting Board.

It had been estimated that between 80 and 90 per cent of the manufacturing and producing resources of the European countries were engaged in the making of supplies for their armies, and that in the event that the United States should become involved in an armed conflict with any first-class foreign power an equal percentage of the countries manufacturing equipment would be needed in this same service. It was realized that America had numerous plants, great quantities of tools and machinery, and a large number of skilled workers, but that it was unorganized and uneducated for the national service. In European countries engaged in the war motor-car factories had been converted into shell factories, and practically every line of industry found that its equipment was suitable for the making of some article, or part, for the munitioning of the armies and navies. Watchmakers were making and adjusting shell fuses; jewelry houses were making periscopes for both submarines and other uses in making observations from the trenches; manufacturers of machinery were turning out thousands of shells; makers of textile machinery were delivering field kitchens, and so on through thousands of items which go to make up the needs of a fighting line. It is upon private industry that all hope of quantity production must be based.

In England no record of skilled labor had been kept prior to the war, and as a result men had gone to the front from the factories and could not be brought back to take up their work.

Germany had been building up, through some 40 years of effort, plants for the mobilization of its industrial resources in the event of war, and the following story, told by an eyewitness, indicates the state of preparedness in which that country found itself at the outbreak of hostilities:

In one well-known manufacturing plant in Germany a telegram announcing the declaration of war was received at 2 o'clock in the afternoon. Bells rang throughout the plant and the men filed past the pay widows. Slips of paper were given them carrying instructions. One part of them left the factory at once on the way to concentration points; others proceeded to the storerooms in which were kept gauges, jigs, and tools for use in the production of that material of war for which that plant, through careful governmental prearrangement, was to be held responsible. Still others of the workmen left to report at once as experts in matters of ignition of aeroplanes and motor vehicles. The machinery scarcely stopped. A few hours at the most in shifting jigs and changing set-ups and the change of commercial product to war product had been made.

Briefly, two years of observation of the European war had taught us that organized industry is the foundation upon which we would be obliged to rest any and every plant for the military defense of the Nation.

It was realized by the Committee on Industrial Preparedness that the United States, by prearrangement and in time of peace, while it could work calmly and efficiently, should evolve a plan which would (1) give accurate statistics as to the resources of the country for the production of war materials; (2) evolve a plan through which the mills and factories could receive educational orders on war material for which their plants were suited; and (3) get accurate information as to the number of skilled men employed who should be retained in the industry in the event of hostilities. Briefly, so that within a reasonable time the factories of America could be swung from their regular line of production to Army and Navy work. Certain concerns were already known to be working on foreign war orders, as, for instance, the Linotype Co., which was manufacturing 6,000 fuses a day for the Russian Government, and an electrical concern manufacturing 20,000 fuses a day. It was estimated that there were some 35,000 such concerns in the United States that could be depended upon to furnish materials for the Army and Navy in time of emergency need. It had been found that one of our largest American manufacturers, who started work on an order for one of the foreign Governments, could find only three expert workmen skilled in the manufacturing methods necessary to the production of this particular munition in the United States. It was also realized that the making of munitions was a parts-making business and that parts made in Toledo, Ohio, must fit other parts which may be made in Portland, Oreg., or in Augusta, Ga.; moreover, that these parts must fit each other to within a small fraction of the one-thousandth part of an inch.

The making of munitions thus involved a similar standardization to that required by the motor-car industry, but in a very much more refined degree.

It was not strange, therefore, that Mr. Coffin should, upon his election to the Naval Consulting Board and to its Committee on Organization, Manufacture, and Standardization, have the inspiration and incentive to start an industrial preparedness campaign. At that time he could not see its far-reaching importance, or that, based upon it, an organization would be evolved by our National Government for the prosecution of the war.

On January 4, 1916, the presidents of the American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, and American Chemical Society were called together by Mr. Coffin at a luncheon at Delmonico's, Forty-fourth Street and Fifth Avenue, New York City. At this meeting the plan for a preparedness campaign and industrial inventory was laid before the presidents in attendance at this meeting, at which were also present Mr. W. L. Saunders and Mr. Thomas Robins, of the Naval Consulting Board. The presidents of these societies were asked to consider the proposition for the utilization of the membership of their organizations for taking an industrial inventory of the United States, and about one week later (Friday, January 7, 1915), a meeting was held at the Machinery Club, 30 Church Street, New York City, at which were present the five presidents of the above-mentioned societies, including Mr. John J. Carty, chief engineer of the American Telephone & Telegraph Co., who was at that time president of !e American Society of Electrical Engineers. Mr. Carty, in his capacity of chief engineer of the American Telephone & Telegraph Co., knew of the ability and capacity of Mr. Walter S. Gifford, chief statistician of the American Telephone & Telegraph Co., and at a conference between Mr. Coffin and Mr. Carty it was decided to request him to undertake the management of the campaign. The company loaned Mr. Gifford to the Industrial Preparedness Committee, and he took entire charge of the management of the New York office, which was established at 29 West Thirty-ninth Street, New York City.

On January 13, 1916, Woodrow Wilson, President of the United States, wrote a letter to each of the five engineering societies. The following letter to the American Institute of Mining Engineers is the type of letter which was written to each one of the societies:

THE WHITE HOUSE,
Washington, January 13, 1916.

MY DEAR SIR: The work which the American Institute of Mining Engineers has done through its members on the Naval Consulting Board is a patriotic service which is deeply appreciated. It has been so valuable that I am tempted to ask that you will request the institute to enlarge its usefulness to the Government still further by nominating for the approval of the Secretary of the Navy a representative from its membership for each State in the Union, to act in conjunction with representatives from the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Electrical Engineers, and the American Chemical Society for the purpose of assisting the Naval Consulting Board in the work of collecting data for use in organizing the manufacturing resources of the country for the public service in case of emergency. I am sure that I may count upon your cordial cooperation. With sincere regard,

Cordially, yours,

WOODROW WILSON.

Mr. W. L. SAUNDERS,
President American Institute of Mining Engineers, New York City.

The following letter was sent to the directors in each State:[1]

MY DEAR ——: In requesting you, which I herewith take much pleasure in doing, to serve as a member of the board of directors of the Organization for Industrial Preparedness for the State of ———, and as associate member of the Naval Consulting Board, I am given opportunity to impress upon you the value and importance of the work which you are now about to take up. At the same time I desire to tender you the hearty thanks and deep appreciation of the department and of the administration for the definite service that you, in the most nonpartisan and unselfish spirit, are about to render to the Government and people of the United States.

There can be no higher service to the country than that contemplated in the plans of the Committee on Industrial Preparedness of the Naval Consulting Board, which has in hand the general direction of the work in question. The war in Europe has taught us that industrial preparedness is the foundation rock of the national defense, and to the end of accomplishing it in full measure you can contribute a large and patriotic service for the common interest of this Republic.

Very sincerely, yours,

JOSEPHUS DANIELS,
Secretary of the Navy.

The secretaries of the five engineering societies which had volunteered to assist in the campaign met, bringing a complete list of their members, classified by States. It was decided to appoint one member from each society for each State to act for the society without compensation and to assist in the carrying out of the work. This made a committee of five for each State, which committee was to have turned over to it the membership of the societies in that State to act as volunteers to assist in the work. The members to be chosen in each State were selected at this conference by the representatives of the five societies. The conference then selected one of the five members to act as temporary chairman and to assume the responsibilities of calling the first meeting of the five State directors.

Notices were sent to each of the members of the societies appointed on these State committees, a special notice being sent to the member

[1] For List of directors, see Appendix, p. 236–243.

who was appointed temporary chairman, urging him to call a meeting promptly and to elect a permanent chairman at that meeting. An outline of the plan and a sample of the questionnaire[1] were sent at the same time in order to inform the State committees of the scope and plans of the work.

In selecting the members of these State committees consideration was given to the affiliations of the society members chosen; that is, it was thought wise to have at least one man connected with a manufacturing enterprise, and perhaps one connected with a college, etc. The idea was not to get five college professors on a committee.

This resulted in the mobilization of some 250 men, among them being some of the leading engineers and scientists of the country.

It was realized, of course, that a considerable amount of financing would be required in the consummation of the work. In the beginning there had been a hazy understanding that the Navy Department would supply the money, but the legal restrictions were found to be such that this was impossible under the law that then existed. The Naval Consulting Board had then no legal status in the governmental machinery, it being merely an advisory group of civilians appointed by the Secretary of the Navy without congressional authorization or any appropriation to meet its expenses. It was decided, therefore, to carry on the work without financial governmental support and each State committee was notified that it must finance itself from money advanced, either by the members of the local committee or by industrial concerns which realized the importance of the task. It is significant of the attitude of American business men and of their realization of the necessity for preparedness that no difficulty was encountered in providing the money for this campaign.

The expenses of the director's office in New York, amounting to something between $20,000 and $25,000 and including many contingent expenses, amounting to probably $10,000 additional, were financed entirely by Mr. Howard E. Coffin personally. The expenses of the New York State organization, amounting to some $15,000 or $20,000, were provided by the business men associated with the New York State campaign. The work in all other States was handled in the same manner. It has been estimated that, all told, something over a quarter of a million dollars were involved in this work, together with actual years in the aggregate of the time of leading engineers of the country, whose services were freely given as volunteers, where the Government would have been absolutely unable to purchase such ability and effort.

The United Engineering Societies Corporation contributed the director's offices rent free to the cause.

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[1] See Appendix, p. 243–247.

It seemed to those who had charge of the work that a large part of its success would depend upon the speed and enthusiasm with which it was carried on. As it was quite impossible to bring all of the members of the State committees into conference and discuss the matter in full, and as the men composing these State committees were, for the most part, of experience and understanding, it seemed wise to allow each State to handle its work in its own way within certain limits. In other words, it was not practical, in view of the desire for speed, to lay down the exact methods of procedure, which might, in many cases, have not fitted the conditions and have really, in the end, interfered with the carrying on of the work. In any case, it would have reduced the members of these committees to the position of clerks, which would have been a mistake, from a psychological standpoint.

The responsibility for the success of the industrial inventory in each State was placed with the State committee, and in final analysis responsibility for action rested with the chairman of the State committee. The work was carried on with surprising speed and tremendous enthusiasm.

Some committees organized into county units, appointing committees of five in each county, each one of the five representing one of the engineering societies. Every committee found it more advantageous to list their large industries and large industrial plants and assign individual plants to individual members of the society in that State. Some committees relied on correspondence, rather than on personal visit. The committees made considerable use of the publicity matter which was sent out and they seemed to generally understand that nothing could be done without the sympathetic cooperation of the public.

The broad aim of the inventory was to secure information as to the producing facilities of the country in the production of war materials needed to carry on war. That is, it was desired to learn the machinery and equipment (equipment meaning both buildings and working organizations) that could be turned over in time of need for the production of materials for the Army or Navy. With this broad aim it was, therefore, reasonable not only to take the inventory of the machine shops, but of ice-cream factories, phonograph factories, and industries which were apparently remotely connected with any product needed for use in war, the idea being that if it were necessary these factories, in an emergency, could be converted into producing either complete units of equipment needed for war or piece parts.

President Wilson was impressed by the necessity of taking an industrial inventory of the country and addressed the following letter to the business men of America:

THE WHITE HOUSE,
Washington, April 21, 1916.

To the Business Men of America:

I bespeak your cordial cooperation in the patriotic service undertaken by the engineers and chemists of this country under the direction of the Industrial Preparedness Committee of the Naval Consulting Board of the United States.

The confidential industrial inventory you are asked to supply is intended for the exclusive benefit of the War and Navy Departments, and will be used in organizing the industrial resources for the public service in national defense.

At my request, the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Chemical Society are gratuitously assisting the Naval Consulting Board in the work of collecting this data, and I confidently ask your earnest support in the interest of the people and Government of the United States.

Faithfully, yours,

WOODROW WILSON.

Simultaneously with the appointment of the committees, there was started a publicity campaign to educate the public on the question of preparedness. The backbone of this educational campaign was a straight drive through the newspapers which had its genesis in a luncheon organized by Mr. Coffin at Delmonico's, in New York, on March 14, 1916,[1] at which were present the leading publishers and editors of newspapers and magazines centered in New York.

It was the response given by these men that made possible the success of the campaign which, in essence, was simply a pioneer selling proposition and without whose efforts the work of the committees appointed to take the inventory in the various States and the industrial, engineering, and scientific experts who cooperated with them could not have been brought to a real fruitage.

As a result of this combination and cooperation of the engineers with the publicity campaign, one of the swiftest pieces of work ever done in the United States, for a job of a similar size, was accomplished. The entire inventory took about five months.

Special credit should be given to the artists and the Associated Advertising Clubs of the World, the American Press Association (later absorbed by the Western Newspaper Union), and also the house organs of the country, who helped so largely to speed the propaganda of preparedness.

Through the agency of the American Press Association and Mr. Courtlandt Smith, its president, the advertisements of the prepared-

[1] For list of those present, see Appendix, p. 247.

ness campaign were sent to a list of from 15,000 to 20,000 newspapers, and they were asked to run the advertisements in the national interest. A tremendous response was received to this appeal.

Possibly the most effective work of the advertising clubs was done by the poster division. It arranged for an enormous lot of space on the billboards over the country, and the following artists designed the posters, which attracted an immense amount of attention: Louis Fancher, James Montgomery Flagg, Charles Dana Gibson, Milton Bancroft, William de Leftwich Dodge, and others.

Most everyone will remember the cartoon by James Montgomery Flagg entitled "Armless Columbia" (with apologies to Venus de Milo), showing Venus with a blue cap of stars and with her thighs and legs draped with wide red and white stripes, and a naked torso, armless.

As a partial indication of the extent to which the publicity campaign was extended, it is estimated that through 196 newspapers, covering the whole of the United States, a circulation of 5,956,374 was reached; 22 magazines carried articles, and a large percentage of the 125 house organs also carried the article. Many of them also ran inspirational material on the industrial movement, besides the publicity that came from articles in 41 trade papers.

After the first initial movements the situation in regard to the campaign was that the State committees of the societies, who had been appointed as above described, five for each State, and a temporary chairman, had met in their respective States and an outline of the plan of campaign and a sample of the questionnaire were sent to the State committee, who informed them of the scope and plans of the work.

In May, 1916, there was held in New York City one of the largest parades known, lasting from morning until well after dusk, in which 150,000 civilian marchers took part, as an appeal to Congress and the people of the United States in behalf of preparedness. Other preparedness parades were held in other cities throughout the country, and there is little doubt but what these perhaps were the outgrowth of the propaganda of the Committee of Industrial Preparedness of the Naval Consulting Board.

When it was known that Mr. Thomas A. Edison intended to march in this parade he received many letters threatening his life because of his efforts toward preparedness and because of the fact that his inventive ability would be turned against the foes of the United States should we enter the war. Mr. Edison, notwithstanding these threats, believing that his marching might possibly help the cause of preparedness, and against the wishes of his family and many friends, covered the entire line of march. Two Secret Service men walked on each side of him. The members of the Naval Consulting

Board marched with him, and the board led the engineers' division of this parade.

No doubt Mr. Edison's active participation in the plea for preparedness gave the movement much weight. He was enthusiastically greeted and applauded, and seemed to receive more applause than any other marcher. The daily newspapers published his picture as a marcher and commented at length on his part in the parade and its effect on the preparedness campaign.

While this was going on the publicity work was also going forward. As a result, the State committees found the manufacturers and business men more and more responsive as the publicity campaign matured to cooperating with them in the taking of the inventory.

A brief outline of the organization of the inventory is as follows:

1. Selection by each of the five great technical societies of one American citizen from each State in the Union, as per President Wilson's request of January 13.

2. The formal appointment by the Secretary of the Navy of the men so selected as State directors of the Organization for Industrial Preparedness and associate members of the Naval Consulting Board.

3. Each State board of directors consisting of the five men thus appointed to organize for business—electing chairman and secretary.

4. The organization under each State board of a corps of field aids selected from the combined membership of the five technical societies within that State.

5. The issuance by the Naval Consulting Board to each State board of complete information as to the work in hand, the objects to be attained, suggested methods of procedure, lists of members within the State of the five technical societies and all available data as to the industries of the State.

6. Examination by the State board of their territory with reference to the number and geographical distribution of industries with relation to the field aids available for the inventory.

7. Issuance by the State boards to the field aids of instructions and blank forms as supplied by the Naval Consulting Board.

8. Examination and checking by the State boards of all completed field reports. Following up men to see that reports are sent in properly. Checking reports and supplying any data lacking before sending them to Consulting Board.

9. The continuance of the organization thus formed in order to insure to the Government the backing of the full industrial strength of the country and to secure for the largest practicable number of industrial concerns such an amount of Government business as will keep them in touch with the requirements of the Army and Navy.

NOTE.—For sample of the industrial inventory blank, see Appendix, p. 243–247.

Among those present, at different times, were Maj. Gen. C. C. Williams (who later became Chief of Ordnance); Col. Smith, of the Quartermaster Corps; and Maj. Douglas MacArthur, of the General Staff (who later became Gen. MacArthur).

The actual work of classifying returns in respect to the purpose to which the various plans would be put in case of war was done by Prof. MacLauren, of Princeton University, and Col. R. H. Somers.

The results of this campaign, which in many ways was one unique in vigor and vision, played a very definite part in the measures for national defense which became a law when the Council of National Defense was formed. It drove home to the people and Government of the United States the vital, irresistible truth that in war, as now waged, battles are won not alone by fighting men, but by the fighting industries of a nation.

The act creating the Council of National Defense was approved August 29, 1916, but the council was not fully organized until March 3, 1917.

During the time that the industrial preparedness campaign was going on it became more apparent, as it progressed, that a legalized body of some sort, with definite status and authority, should be organized to carry on this work. As pointed out above, the Naval Consulting Board, by its method of creation, had no legal status, and it was evident that if the best results were to be obtained not only would the existing laws require revision, but there must also be created a properly legalized body, under which might be organized the scientific and industrial resources of the country. To aid in bringing about this legislation several conferences took place between Messrs. Godfrey, Crampton, and Coffin, they being apparently most intimately connected, or most interested in, the accomplishment of this industrial and scientific organization.

Secretary of War Garrison, impressed as he was with the necessity of preparedness, encouraged Drs. Godfrey and Crampton in their work, and this occurred at a time when the country was being flooded with the publicity matter of the campaign inaugurated by the Naval Consulting Board, and with preparedness parades in our largest cities and other manifestations brought about by the initial movement made by the Committee on Preparedness of the Naval Consulting Board. People were all beginning to think in terms of industrial preparedness and the necessity for it. The legislation creating the Council of National Defense was added to the Army bill undoubtedly largely in consequence of this educational work. At about this time, Mr. Coffin had many conferences with such men as Maj. Gen. William Crozier, Chief of Ordnance; Rear Admiral Samuel Gowan, head of the Purchase Division of the Navy; and other men on whom the responsibility for the utilization of the industrial resources of the country rested.

The organization meeting of the Council of National Defense was held in Washington on December 11, 1916, at which meeting the seven civilian members of the Advisory Commission met for the first time with the six Cabinet offiners forming the council.

The personnel of the council was as follows: Secretary of War, Newton D. Baker (chairman); Secretary of the Navy, Josephus

Daniels; Secretary of the Interior, Franklin K. Lane; Secretary of Agriculture, David F. Houston; Secretary of Commerce, William C. Redfield; Secretary of Labor, William B. Wilson.

The personnel of the Advisory Council was as follows: Daniel Willard (chairman) (president Baltimore & Ohio Railroad), Howard E. Coffin (vice president Hudson Motor Car Co.), Julius Rosenwald (president Sears, Roebuck & Co.), Bernard M. Baruch (banker), Dr. Hollis Godfrey (president Drexel Institute), Samuel Gompers (president American Federation of Labor), Dr. Franklin Martin (secretary general American College of Surgeons, Chicago).

The duties and functions of the council, as defined by section 2 of the Army appropriation act approved August 29, 1916, are as follows:

That a Council of National Defense is hereby established for the coordination of industries and resources for the national security and welfare to consist of the Secretary of War, the Secretary of the Navy, the Secretary of the Interior, the Secretary of Agriculture, the Secretary of Commerce, and the Secretary of Labor.

The Council of National Defense shall nominate to the President, and the President shall appoint, an Advisory Commission consisting of not more than seven persons, each of whom shall have special knowledge of some industry, public utility, or the development of some natural resource, or be otherwise specially qualified, in the opinion of the council, for the performance of the duties hereinafter provided. The members of the Advisory Commission shall serve without compensation, but shall be allowed actual expenses of travel and subsistence when attending meetings of the commission or engaged in investigations pertaining to its activities. The Advisory Commission shall hold such meetings as shall be called by the council or be provided by the rules and regulations adopted by the council for the conduct of its work.

It shall be the duty of the Council of National Defense to supervise and direct investigations and make recommendations to the President and the heads of executive departments as to the location of railroads with reference to the frontier of the United States, so as to render possible expeditious concentration of troops and supplies to points of defense; the coordination of military, industrial, and commercial purposes in the location of extensive highways and branch lines of railroad; the utilization of waterways; the mobilization of military and naval resources for defense; the increase of domestic production of articles and materials essential to the support of armies and of the people during the interruption of foreign commerce; the development of seagoing transportation; data as to amounts, location, method and means of production, and availability of military supplies; the giving of information to producers and manufacturers as to the class of supplies needed by the military and other services of the Government, the requirements relating thereto, and the creation of relations which will render possible in time of need the immediate concentration and utilization of the resources of the Nation.

That the Council of National Defense shall adopt rules and regulations for the conduct of its work, which rules and regulations shall be subject to the approval of the President, and shall provide for the work of the Advisory Commission, to the end that the special knowledge of such commission may be developed by suitable investigation, research, and inquiry and made available in conference and report for the use of the council; and the council may organize subordinate bodies for its assistance in specal investgations, either by the employment of experts or by the creation of committees of specially qualified persons to serve without compensation but to direct the investigations of experts so employed.

That the sum of $200,000, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to be immediately available for experimental work and investigations undertaken by the council, by the Advisory Commission, or subordinate bodies for the development of a director, expert, and clerical expenses and supplies, and for the necessary expenses of members of the Advisory Commission or subordinate bodies going to and attending meetings of the commission or subordnate bodies. Reports shall be submitted by all subordinate bodies and by the Advisory Commission to the council, and from time to time the council shall report to the President or to the heads of executive departments upon special inquiries or subjects appropriate thereto, and an annual report to the Congress shall be submitted through the President, including as full a statement of the activities of the council and the agencies subordinate to it as is consistent with the public interest, including an itemized account of the expenditures made by the council or authorized by it, in as full detail as the public interest will permit: *Provided, however*, That when deemed proper the President may authorize, in amounts stipulated by him, unvouched expenditures and report the gross sum so authorized not itemized.

As pointed out in an address delivered by the Hon. Newton D. Baker, Secretary of War, before the Cleveland Chamber of Commerce on September 26, 1916, Mr. Howard E. Coffin did perhaps the greatest service that has been done for America by any private citizen in the last 50 years by his having inaugurated and conducted the industrial preparedness campaign of the Naval Consulting Board.

The results of this campaign finally reached the halls of Congress and resulted in a response by that body in the creation of the Council of National Defense to take over and keep up the work which Mr. Coffin had started through the instrumentality of the industrial preparedness campaign of the Naval Consulting Board.

It will be recalled that whereas Mr. Coffin had initiated and conducted the campaign, Mr. W. S. Gifford acted as supervising director and Mr. G. B. Clarkson as publicity man of the campaign.

Shortly after the creation of the Council of National Defense all of these men were absorbed by it, Mr. Coffin becoming a member of the Advisory Commission of the council, Mr. Gifford its director, and Mr. Clarkson its secretary. They took with them to Washington all of the files of the industrial inventory of the country which they had taken and turned them over to the Council of National Defense.

The history of this transition period was very well set forth by Secretary of War Baker in his address before the Cleveland Chamber of Commerce above referred to. In that address he said:

One of the first manifestations of the response to this difficulty was the appointment of the Naval Advisory Board, with Mr. Edison as its head and containing a large number of eminent inventors and scientists whom it was thought could contribute something to the national defense.

They immediately began to make suggestions, some of them very wise and helpful, but in the meantime, Europe was standing by with its spelling book in hand. As fast as they learned to spell one word, Europe propounded another, and so this board was driven from its simple and elementary task of merely suggesting ingenious and newly invented devices to the Navy, and it began to realize what I have suggested, that the whole industrial and commercial forces of the Nation had to be organized. And so they appointed a committee of which Mr. Coffin is the chairman, a man who has done perhaps the greatest service that has been done for America by any private citizen in the last 50 years.

After stating that we must have this great continental empire of ours so organized that every part of it will be intimately corelated with every other part, so as to summon at a touch every part of the Nation for the general defense, he goes on to say:

I do not know how many of you know what has been done, but Mr. Coffin has organized a committee. He is himself an automobile engineer, manufacturer, and expert, a man with large business relations and who knows the manufacturing business from the private side. He has organized his committee and taken up correspondence with 30,000 manufacturers in this country having an annual output of $100,000 or more, and has put to them a series of questions aimed to determine the uses to which those plants could be put in the time of a national emergency, and seeking to find out what the spirit is of the men who operate those plants and own them, as to whether they would be willing to join in a preparedness partnership with the Federal Government, so as to organize their private business as not to interfere with its normal operation in peace time, but to put it upon a basis such that in the event of a great national peril all that would be necessary would be to touch a button somewhere in Washington and all those industries, scattered throughout the land, would instantly cease to have the private idea, cease to have the individual idea, and take their places in a coordinated system of national production for the common defense of the kind that they call preparedness on the other side. Now, this committee of Mr. Coffin has submitted a great list of questions to manufacturers. It has seemed to probe into their private business, has asked questions which the ordinary business man conceals from his competitor. It has been in a sense an inquisition into private business; and yet I delight to be able to tell you that the response has been instant and filled with high patriotic promise. Manufacturers throughout the country everywhere have scheduled their businesses and their assets and laid down on paper the possibilities of their plants, so that when that great census is tabulated, when the results of it are summed up, we will have in Mr. Coffin's bureau an indexed card catalogue of the industrial and manufacturing resources and possibilities of the Nation.

Now, at the same time that that has been going on a couple of scientists, closet men, men who burn the midnight oil, and whose names you don't know, and whose names I can't tell you, because they are so modest they wont let me tell it, have been making this kind of inventory and getting this kind of information. They have been taking each product that is vital to the life of the Nation and scheduling its integral parts, as, for instance, a chemical compound which might be necessary to the life of the Nation. They are finding out of what ingredients it is made, whence those ingredients can be procured, and how they can be put together, and they are making great illustrative sheets, so that if we came to a time of stress and the Government, acting for us, should desire, for instance, to have smokeless powder—I use a war-material illustration, although their inventory covers the materials of peace as well as of war—it turns over a leaf and finds that it is made of nitric acid and cotton. It finds that cotton is one of the staple products of the country and therefore there need be no worry about it. It finds that nitric acid is made of Chile saltpeter, so that if our communication with Chile were interrupted we would have to rely upon our accumulated supplies of Chile saltpeter. And then they give the substitutes. If we can't get Chile saltpeter, nitric acid can be made out of ammonia liquor, which is a product of ammonia—we find this in the chart—and then it is passed over a nest of heated platinum wires in order to get the nitric acid out of it. And we find the weak point to be the apportioning of the ammonia liquor. We find other processes enumerated, the one known as the cyanamid process, and the so-called arc process, and on that chart we have exactly what the Nation's possibilities are. We know where our main reliance is; we know that if that is cut off our next best step is to do it in this fashion; and if that is prevented or is not adequate, that the next step is in another direction. All the way through our industrial and commercial life, not only in war material but those needed in daily life, we find this series of charts, tracing the materials and combinations, pointing out the weak spots, pointing out the substitutes, and sometimes the actual number of days necessary to produce certain parts of highly organized and intricate machines. So that we are having a more complete inventory of our national resources along those lines than perhaps most men in this country knew was being prepared.

And then Congress has responded to that. It has put into one of the Army bills a provision for a Council of National Defense. I rather regret that its name has the defense idea so prominently in it. My brother Houston will recall that when we were discussing names we all took a turn at it, and we finally decided on a name very much more complicated than that—the council of executive information—and we found out what we meant by it by looking in the dictionary. When we sent that suggestion down to Congress they were too busy to consult the dictionary and decided to take a name they could understand without looking it up. And so they provided by law for a Council of National Defense, to consist of the Secretaries of the Navy, of Agriculture, of Commerce, of Labor, of the Interior, and of War, and they are to have an advisory council of citizens, to be appointed by the President because of their peculiar eminence in and their knowledge of the great fundamental and staple industries and commercial undertakings of the Nation.

Now, when that body is organized it is to take over and keep up the work which Mr. Coffin has been doing, the work which these individual scientists have been doing, and there will be established down in Washington a central bureau with an adequate complement of experts and clerical assistants to keep this information up to date, so that it will be a reliable datum when we come to need it.

At the first meeting of the council a plan of organization of the council was formulated and adopted similar to that used by the Committee of Industrial Preparedness of the Naval Consulting Board. Each of the seven civilian members of the Advisory Commission was made the chairman of a subcommittee.

The work of the Committee of Industrial Preparedness of the Naval Consulting Board was carried forward on a much broader scale by the subcommittee on Munitions and Manufacturing of the Council of National Defense, of which Mr. Howard E. Coffin was made the chairman. On December 12, 1916, some 18,654 industrial inventories and steel filing cases of material, together with a considerable portion of the working personnel of the New York office of the Committee of Preparedness was moved bodily to Washington, the material being sent down on an express car, and one of the officers of the organization traveling with it.

The data contained in the inventories had been classified and tabulated and were first used in the report of the board of Army officers, headed by Col. Francis J. Kernan, United States Army, on Government manufacture of arms, munitions, and equipment, dated January 4, 1917, and referred to the Committee on Military Affairs of the United States Senate, same having been printed by the Government Printing Office and numbered Document 664. After the declaration of war, the data in these files were used by the various committees and boards of the council and by the various purchasing divisions of the War and Navy Departments. New reports and inventories were being constantly received by the Council of National Defense and the information kept up to date and made available to the Government organizations in need of it.

Although the Council of National Defense, as set forth above, was authorized by act of Congress August 29, 1916, the appointments to the council were not made until some time in November, and the first meeting, as above set forth, was held December 11, 1916.

Briefly, the aim of the council and its agencies was to serve as a channel through which the best professional and industrial intelligence of the country could make itself most effectively valuable to the Government departments. Necessarily, much of the accomplishment implied in such a function had to be carried through by personal contact in the smoothing out of the serious obstacles in the war machinery and to coordinate the governmental and industrial systems of the Nation.

Although it was not generally recognized, the Council of National Defense was, in fact, the War Cabinet of the administration. The Secretaries of War, Navy, Interior, Agriculture, Commerce. and Labor that made up the personnel of the council were the executive heads of the various departments which they represented. They were, therefore, in a position to execute, through the machinery of their various departments, the plans which were brought forth in the meetings held by the council itself and its Advisory Commission of seven members.

The usual procedure, through which action was initiated by the Council of National Defense, was for the Advisory Commission to meet and pass resolutions, recommending to the council, composed of Cabinet officers, as above described, that certain action be taken. After discussion of such resolutions, either by the council sitting as such, or in a joint meeting of the council and Advisory Commission, the council, if it concurred with the resolution of the commission, passed a resolution recommending to the executive department of the Government interested or involved the action recommended by the Advisory Commission.

As a matter of fact, a resolution passed by the Council of National Defense stood second only in importance to an Executive order of the President of the United States. It was practically the act of the Cabinet without the President being present. The President of the United States was not present at these meetings and did not make it a necessary requisite of action that he be consulted or taken into consideration in the resolutions passed by the council. The Secretary of War, however, as chairman of the council, consulted the President upon matters of importance.

The governmental departments represented in the council did not have the necessary business experience or information, or the men of proper training for the work involved in conducting the war. The Advisory Commission supplied this deficiency and focused upon the problems knowledge based upon lifetime experience in industry, together with a knowledge of men and affairs and the confidence and good will of the country.

The Advisory Commission of the Council of National Defense might be likened to the clutch of the machine. They connected up the country at large with the executive mechanism, the executive mechanism being the governmental machine, represented by the Secretaries of War, Navy, Interior, Agriculture, Commerce, and Labor. This clutch (the Advisory Commission) was the mechanism which set the country in motion for the purpose of winning the war.

The law is very clear and explicit and does not permit the Government to accept the services of any man without compensation. It says, "Nor shall any department or any officer of the Government accept voluntary service for the Government, or employ personal service in excess of that authorized by law, except in cases of sudden emergency involving a loss of human life or the destruction of property." This was passed on February 27, 1906, and it is found on page 49, section 3, volume 34, of the Statutes at Large.

This statute was largely instrumental in giving rise to that great class of voluntary civilian workers which cooperated with the Council of National Defense, known as "dollar-a-year men."

The creation of the Council of National Defense bridged over the chaotic period and a period of inadequacy and lack of proper organization and personnel to handle a terrific job. Take, for instance, a good manufacturing concern; it is doing big things to double its capacity in a year, but the War Department was asked to multiply itself so many times that it was a stupendous undertaking. Many of the men who did the preliminary work under the Council of National Defense were later absorbed in the Army and Navy.

The declaration of war brought about the growth of numerous war organizations and stimulated existing civic, benevolent, and patriotic societies to undertake activities related to the war. All of these organizations naturally turned to Washington for information and advice, and the office of the Council of National Defense was besieged with requests of one kind or another. It became obvious that decentralization was necessary and that the work of these organizations should be directed by some central body in each State. On the other hand, it was equally necessary that there be some centralizing organization at Washington to act as a clearing house between the States, to make the services of the organization in the several States available to the various branches of the Federal Government. To meet this need, on April 9, 1917, the Secretary of War, in his capacity of chairman of the Council of National Defense, issued to the governors of all the States and to the Commissioners of the District of Columbia a request to create State councils of defense or similar committees, with broad powers, representative of the resources, industries, and activities of each State to cooperate with the National Council. The method of organization was patterned after the organization of the Committee of Industrial Preparedness of the Naval Consulting Board.

Following this action, a conference was held in Washington on May 2, 1917, and remained in session for two days. Every State in the Union sent representatives, among whom were the governors of 12 States. The conference was opened by the chairman of the Council of National Defense, and was later addressed at the White House by the President of the United States.

Frank and thoroughgoing explanation of the outstanding needs of the Nation in the prosecution of the war with Germany was given to the State representatives and a specific outline was made as to how the State defense activities could best be linked up with the work of the Federal Government in the most intelligent and efficient coordination for the Nation's defense.

Within four weeks of the conference State councils had been organized in nearly every State. By the end of June this national chain of State councils of defense had been completed. In all States the councils were created by appointment of the governor or by act of the legislature, and the members were chosen on a nonpartisan basis, representing the various interests of the State.

Under the State organizations county and other subsidiary councils of defense were organized and in some cases even extending to townships and municipalities. It was found that local councils which knew the local conditions were better able to undertake work in which personal touch or an understanding of local conditions was of value. These State councils rendered effective aid to the Commercial Economy Board to eliminate the return of unsold bread and helped materially to eliminate this wasteful practice, which assisted the Department of Agriculture to increase the food supply; it assisted the Department of Labor in the organization of the Boys' Working Reserve and in the building of a system of labor exchanges; the Treasury Department used the organization of State councils to float the first Liberty loan of 1917.

The method that the council used for getting results was to create a committee on a particular subject, which it selected from well-known men in the manufacturing and business world. These men were then charged with the responsibility of organizing the particular field in which they worked and were masters of, for war purposes. As a type of thing which the Council of National Defense was doing each day might be mentioned the Committee on Emergency Construction. Numerous cantonments had to be constructed in order to provide for the training and housing of troops, and numerous additions had to be made to Government arsenals and other manufacturing concerns engaged in the production of war materials and supplies. Immediately it became apparent that the ordinary method of advertising for bids and awarding the contract to the lowest bidder could not be followed, because of the necessity of getting the work under way at once, prior to the developments of completed plans and specifications which could be used as a basis for competitive estimates. In other words, construction and design would have to go concurrently, especially since the sites for these cantonments had not even been determined. Since no form of Government contract met this situation, a new form had to be developed: (*a*) Inquiries were sent to the leading architectural firms throughout the country; (*b*) to the chief engineers of leading railroads; (*c*) to engineers of naval stations of the Government; (*d*) to a selected list of members of the American Society of Civil Engineers. In all, some 3,000 inquiry blanks were sent out.

Lists were made from the returns, which were cross indexed and further subdivided as regards localities and magnitude of operations which, through experience, the various contractors were qualified to undertake. The credit rating of the concerns and other information was added to that received on the inquiry blank. From every available source the list of contractors was expanded and information built up until the committee had in hand probably the most complete survey of the contracting field that has ever been made. From these lists, as the various cantonment sites were selected, recommendations of contractors were made by the committee at the request of the Quartermaster's Department, and upon their being approved by the General Munitions Board of the Council of National Defense the awards of contracts were made.

In April and May, 1917, the question of the construction of the cantonments confronted the War Department, and Col. I. W. Littell was assigned by the Secretary of War to take charge of cantonment construction. The Committee on Emergency Construction of the Council of National Defense immediately set about to assist him in building up an organization, an engineering division to develop plans and specifications, an administration division to direct actual construction of cantonments in the field, a purchasing division to mobilize the enormous quantity of material required in connection with cantonment construction (the providing of proper transportation facilities, etc.), and a finance division to keep the complex accounts necessitated by the size of the operation. The committee further suggested the names of various men who seemed to them particularly fitted to head the different departments of this work. The suggestions were largely accepted and the chart of the organization was drawn up under Col. Littell's direction and submitted to the Secretary of War and approved by him.

This was in May, 1917, at which time the commissioned personnel of the division consisted of only three officers. This step was recommended by the General Staff, acting in accordance with the advice of civilian construction experts on the Council of National Defense.

One year later the personnel of this division had grown to 263 officers and 1,100 civilians in Washington—the best constructors, engineers, draftsmen, managers, purchasing agents, and other specialists obtainable by the Government; there were hundreds of other officers and civilian experts in the field for this organization; it had an enlisted personnel of some 16,000 men and employed over 200,000 laborers and craftsmen.

An investigation of the sites selected for cantonments was made and another subcommittee appointed through which an appeal was made to engineers, town planners, and sanitary engineers to aid in studying the conditions at each cantonment site and submit a report thereon. They studied particularly transportation facilities, topography, water supply, and sewage disposal and actively cooperated with Col. Littell and the engineering organization in solving the problems that the reports brought in.

When the construction of cantonments began, representatives of the different industries were called to Washington by the Council of National Defense and requested to organize in such a way that the Government could deal as nearly as might be with a single individual representing that whole industry. The Government was thus put quickly in touch with all lines of the building business. The subcommittee also prepared a report dealing with the form of the Government contract with engineering concerns. It was an effort to standardize the business arrangement for engineers precisely as matters had been standardized for the engagement of contractors.

The above is described at length in order to give an idea of the character of the work which the subcommittees of the Council of National Defense performed. Annexed hereto is a list of the committees of the Council of National Defense, which shows how far-reaching the activities of the council and its subcommittees were.

Subordinate bodies of the Council of National Defense were Aircraft Production Board, Committee on Coal Production, Commercial Economy Board, Committee on Shipping, Committee on Women's Defense Work, International Advisory Committee, General Munitions Board, Munitions Standards Board, Section on Cooperation with States, and Committee on Inland Waterways.

Committees of, and cooperating with, Advisory Commission were those on Telegraphs and Telephones; Railroad Transportation; Cars; Locomotives; Electric Railroad Transportation; Gas and Electric Service; Automotive Transport; National Industrial Conference Board, Supplies; Cotton Goods; Woolen Manufactures; Shoe and Leather Industries; Knit Goods; Leather Equipment; Mattresses and Pillows; Canned Goods; Alcohol; Aluminum; Asbestos, Magnesia, and Roofing; Brass; Cement; Chemicals; Copper; Lead; Lumber; Mica; Nickel; Steel and Steel Products; Oil; Rubber; Wool; Zinc; Engineering and Education; Labor; and General Medical Board.

Subcommittees of General Medical Board of Council of National Defense were those on State Activities and Examinations, Legislation, Hygiene and Sanitation, Statistics, Public Health Nursing, Research, Dentistry, Medical Schools, Publicity, Hospitals, Surgical Methods, Subcommittee on Shell Shock, Special Editorial Committee, Cooperative Committee of Manufacturers, Committee on Standardization of Medical and Surgical Supplies, and Equipment.

Before we became involved in the war, in the spring of 1916, a meeting of the National Advisory Committee on Aeronautics, for which an appropriation was carried in the naval bill, was held at the Smithsonian Institution at Washington, which was presided over by Dr. Charles D. Walcott, Secretary of the Smithsonian Institution. At this meeting the aircraft situation, from a military and naval standpoint, was presented. There were present Navy and Army officers and members of many industrial concerns engaged in motor, automobile, and aircraft production. At this meeting there was discussed the needs of the aeronautical industry and it was suggested that the automobile engineers concentrate upon the design and production of aircraft engines and study generally the problems involved in the development of the aeronautical art.

Shortly after this meeting in 1916, Mr. Howard E. Coffin's name was used as a focal point for getting together the diversified interests involved in aircraft work. It was realized that to make this industry a dependable industry in any war-making program, all factional and legal disagreements must be smoothed out and the manufacturers welded together in a strong business association or organization.

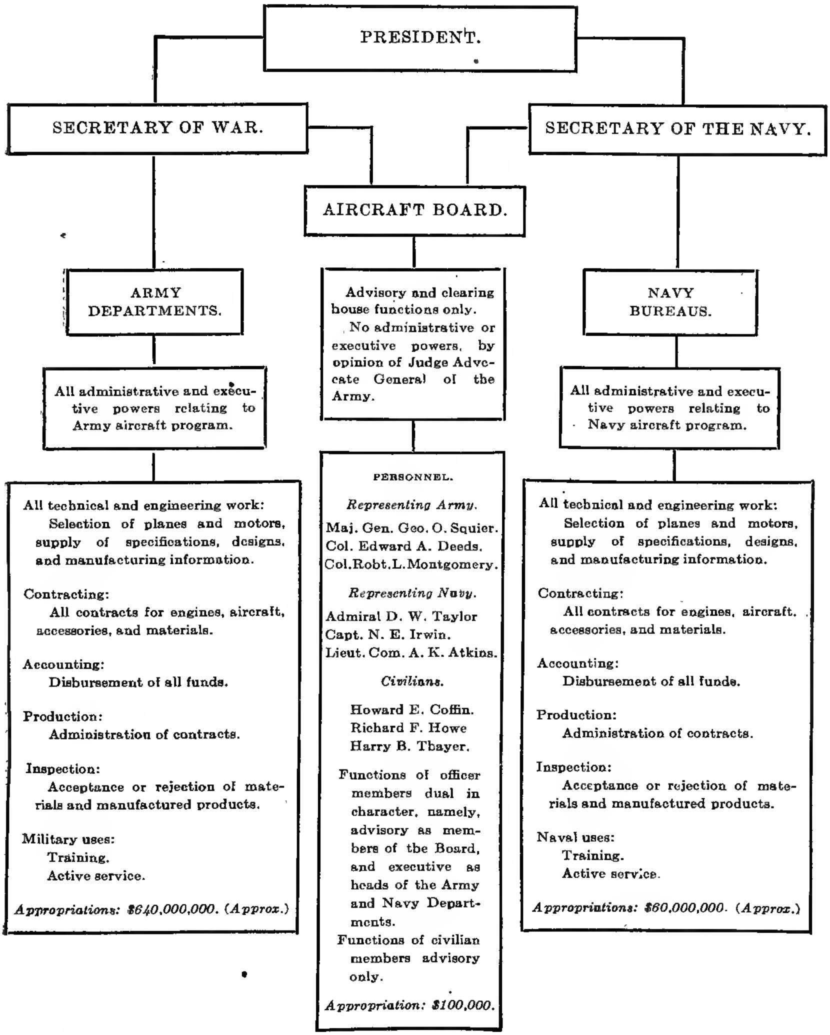
Under the auspices of the Aero Club of America, the first aeronautical exposition was held on January 19, 1917. During the exposition various meetings were held with a view to accomplishing the desired results. First, the possible extension of the National Automobile Chamber of Commerce to include aircraft manufacturers and the change of its society's name to the "National Automotive Chamber of Commerce"; second, the organization of the manufacturers of the aircraft field into an independent association of their own. To this end committees were appointed, both by the aircraft manufacturers and by the National Automobile Chamber of Commerce, to confer together on this proposal. It seemed to be the opinion of all concerned at the moment that an independent association should be formed—the Manufacturers' Aircraft Association resulted. Likewise the subsequent agreement upon a cross-licensing policy, based upon an existing agreement in force in the motor-car field. Through this accomplishment a firm business foundation was laid for the subsequent development of the aircraft industry and a single point of contact provided through which the Government could obtain cooperation and support in meeting its needs.

Mr. Coffin was very active in these matters, and as a result Dr. Charles D. Walcott, chairman of the National Advisory Committee for Aeronautics, requested by letter that the Council of National Defense create an Aircraft Board with Mr. Coffin as Chairman. Mr. Coffin's first act in assuming the chairmanship of this committee was to appoint other members of the committee and to push forward and advise concerning the plans for the increase of the air forces of the Military and Naval Establishments.

An architect of Detroit was called in immediately to coordinate the ideas of the departments relative to the construction and equipment of training fields for aviators, and plans prepared under his direction were immediately turned over for construction. Ground was broken on the first fields in the month of May, 1917, and the

FUNCTIONS AND RELATIONS OF THE AIRCRAFT BOARD.

[Public Document No. 48—65th Congress.]



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first group of fields was in the service of the Government by July 15, 1917.

The Bolling Commission consisted of 103 men and was sent to Europe to study the aircraft requirements of the Army and Navy, this commission landing overseas approximately July 1, 1917. These activities were some of the earliest of any of the activities of the War Department, it being remembered that the United States went to war with Germany April 6, 1917.

The effort of the committees was to build up existing governmental agencies and to bring to them the best thought of the industrial world. The policies and mechanics to put them into operation were visualized and the governmental departments urged to adopt them. In some instances the personnel was directed to operate them from within the service.

The Council of National Defense was therefore the mainspring of many, in fact most, of the policies which affected the economic and industrial life of the civilian population of the United States during the war, with the possible exception of the food control, which, as set forth later, came under Mr. Herbert Hoover.

The Food Administration was first evolved as the Committee on Commercial Economy of the Council of National Defense, under A. W. Shaw. About February, 1917, Mr. Herbert Hoover was called before the Council of National Defense in order to learn as to the food problems concerning the country in the preparation for war. A resolution was passed by the Council of National Defense recalling him from Europe to take charge of the food-conservation activities upon authority of the council. Mr. Hoover, however, very soon saw that the only way that he could handle the situation was to get his power direct from the President, in place of being subject to the Council of National Defense and being subject to certain limitations which would necessarily be imposed through the fact that the Department of Agriculture and the Department of Commerce were both concerned in the administration of the food control, and it was very much better for him to have absolute authority over this matter. This arrangement avoided any conflict that might have come about through there being three departments concerned with the administration of food—the Department of Agriculture, Department of Commerce, and any department that Mr. Hoover might organize to administer the matter. Mr. Hoover was therefore appointed by the President and was directly responsible to him.

It is interesting to note that on February 28, 1917, the Council of National Defense, which, as set forth above, was the outgrowth of the industrial preparedness campaign of the Naval Consulting Board, adopted the National Research Council as its Department of Science and Research. The National Research Council had been organized in April, 1916, by the National Academy of Sciences at the request of the President of the United States to organize the scientific resources of the United States in the interest of national security and welfare.

On February 15, 1917, the Naval Consulting Board was adopted by the council as the Board of Inventions for the Council of National Defense. By this arrangement there became a differentiation between scientific research and inventions, although inventions are frequently the outgrowth of scientific research, particularly where the arts have reached their highly developed state, as they had at the time of the declaration of war.

The Council of National Defense therefore became the parent body of these numerous organizations, which it created and connected up with the war machine. There was overlapping of authority and responsibility in many instances, especially in the beginning, but as time went on each organization became more specialized and its duties more clearly defined. From somewhat nebulous organizations which were created in the beginning, the governmental departments of the Army and Navy drew succor and support and built up their own organization by commissioning in the service men who were first brought to Washington to perform certain functions for the Council of National Defense. As the Army and Navy grew in strength and personnel, it was, in many instances, largely recruited, at least, from sources made available by the Council of National Defense. The activities of some of the committees that were most closely allied with the Army and Navy and should have been almost a part of their organization were somewhat diminished in authority and responsibility with the corresponding increase in personnel and of the authority and responsibility in the Army and Navy Departments, which practically took over the working organizations which had been created by the committees.

The inside history of some of the things of far-reaching importance are most interesting. For instance, the first British mission to this country came to be sent in this way:

Lord Northcliffe's confidential man in the United States, Mr. Pomeroy Burton, on or about April 2, 1917, asked Mr. Howard Coffin, of the Council of National Defense, what ought to be done to help out the situation. Mr. Coffin told him that by far the best thing England could do would be to send a comprehensive mission to this country at once and tell us what to do. Mr. Burton said to Mr. Coffin: "Will you take the responsibility of authorizing me to communicate with Lord Northcliffe on this matter?" Men like Mr. Coffin, in those days, did not care how much responsibility they assumed so long as the work for winning the war went forward, and it was due to men with this point of view that America prepared as rapidly as she did.

The following telegrams were then exchanged between Mr. Pomeroy Burton and Lord Northcliffe:

[To Lord Northcliffe.]

NEW YORK, *April 2.*

I am authorized by Howard Coffin, prominent member Council of National Defense. to send personal dispatch to make clear that this body most anxious arrange immediate exchange of commissions of experts on war problems now arising here on such matters as control of raw materials; contracts; labor problems; restriction output; dilution of labor; women labor enlistment; training, housing, clothing, equipping of troops; care of dependents; transportation; subsistence; transport; medical, hospital, and relief work; voluntary organization. etc., idea being that this great Nation, with wealth of material and man power, lacks efficiency and organization which allied nations have secured through actual war experience past two years. Proposed that American experts be sent to France and England and English and French experts be sent here in quickest possible time, starting this week if possible, cutting red tape, and getting ahead with the work; extremely desirable that a few men like Montague of Munitions Department and Le Bas here at once; publicity end regarded as highly important; also best English and French authorities latest aeroplane construction and training; whole spirit of National Defense Council, which represents best organizing brains of country, is to arrange for quick consultation on these and other important matters. Council feels strongly that instant and decisive action is desired which will provide it with knowledge as to exactly where and how the United States can be of greatest possible immediate effectiveness in war. Do you feel like making their wishes clear in informal way, cable me Plaza Hotel, New York, soon as possible, what steps will be taken. Coffin has read and approved this cablegram, also Keeley.

POMEROY BURTON.

LONDON, *April 4, 1917.*

POMEROY BURTON, *Plaza, N. Y.*

Your cable is before war cabinet this Wednesday morning.

NORTHCLIFFE.

LONDON, *April 4, 1917.*

POMEROY BURTON, *Plaza, N. Y.*

Prime Minister instantly sending strong mission dealing with all subjects mentioned in cable.

NORTHCLIFFE.

NEW YORK, *April 4, 1917.*

LORD NORTHCLIFFE, *Times, London.*

England's prompt action immensely appreciated Washington.

BURTON.

When the British Commission came to this country, headed by the Hon. Arthur James Balfour, a joint meeting was arranged of the Advisory Commission of the Council of National Defense and the Balfour Mission, the Secretary of War presiding. The personnel of this joint meeting was divided into groups, the members of the

Advisory Commission and the members of the visiting delegation being assigned to work with the various Army officers concerned with each phase of the program. The ordnance experts of the Balfour Mission were assigned to the Ordnance Department, etc. From that time on there were many group meetings and the information which the British Mission imparted to those concerned with managing the war in America was largely done in these group meetings. Undoubtedly the information which was brought over by the British Mission and communicated to the Council of National Defense in this manner and to the Army and Navy officers interested influenced many activities in regard to our forces.

Another instance of the taking of responsibility by members of the Advisory Commission was as follows:

One of the members received late one Saturday afternoon a telegram from the chief engineer of the *Vaterland* saying "half a million dollars worth of munition tool equipment, which has been stored at the Hamburg-American docks, has been stolen," the inference being it had been gotten out of the way so it could not be used. It being Saturday afternoon, the cabinet officers of the council were not in their offices, so he called the War Department and the War Department said that they did not want to take charge of it. The Navy Department said it was a Treasury matter, and the Treasury Department washed its hands of it entirely. No one would do anything, so he wired Mr. Malone, collector of the port of New York, wired the admiral in charge of the Brooklyn Navy Yard, and wired the chief engineer of the vessel to get in touch with these men, and wired them to work it out with him. Then copies of the wires were sent to all the departments, and three weeks later the War Department told him that the action was exactly right.

The evolution of the War Labor Board was also interesting. This grew out of the Council of National Defense from the National Industrial Conference Board. A committee of this latter board, which consisted of Messrs. Osborne, Vandervoort, Barr, and Smith, was appointed at Mr. Coffin's request for general discussion pertaining to labor and capital. These men went before their boards of directors and put the whole labor situation up to them and got them to appoint this committee of five men. The Council of National Defense later called a meeting of the National Industrial Conference Board and probably 100 of their number came to Washington and met in the office of the Secretary of War, presenting their side of the labor question. They came in and said, "Here, the war is on; we will do anything the Government wants, and will set aside restrictions and regulations of all kinds," and from this conference there was evolved the idea that no labor situation would be disturbed during the war. This was one of the first steps made during the war toward getting employer and employee together.

There originated in the Council of National Defense also the regulations for restricting the use of gas and electric service, electric signs, and cutting down the use of coal by the citizens of the United States during the war. The Council of National Defense also organized the transportation interests of the country, and this was the first step in what later became governmental direction of the railroads under the Treasury Department.

The evolution of the War Industries Board, which was also an outgrowth of the Council of National Defense, was very interesting. It will be recalled that this board expanded into an immense institution before the war closed and occupied a large building in Washington. It was first called "The Munitions Committee of the Council of National Defense" and was created June 3, 1916. This "Munitions Committee" was really an amalgamation of several committees into the General Munitions Board. Mr. Frank Scott, who was chairman of the Ohio State committee on industrial preparedness, was its chairman. Upon this committee there were some 25 men; it met every morning, and practically every one of the divisions of the Army and Navy Departments sent representatives to its meetings. All contracts of the Army and Navy Departments were cleared by this board on those commodities where any danger point existed, the danger point being the source of supply or quantity of supply. A list was maintained of those commodities which could be purchased freely and on which there was no liability of restriction or conflict between the departments, and another list in which there was danger of difficulty upon those scores, in which latter event any purchases made by any department had to be discussed and cleared by this General Board. This work became so important that the War Industries Board was later, by Executive order, given power directly from the President.

Mr. Bernard Baruch, formerly chairman of the Raw Material Division of the Council of National Defense, became its chairman. This board carried on the work of the industrial preparedness campaign and became the custodian of the inventories which were taken by the engineers of the country, as heretofore set forth. These inventories were supplemented, complemented, and expanded by that board.

Therefore this board and the Council of National Defense and Army and Navy officers of the Procurement Division of the service were brought in contact with the producing resources of the country, which prior to the creation of the Council of National Defense was almost impossible on account of the prohibition of officers from becoming too actively associated with business interests of the country.

The name "Council of National Defense" was given to the parent organization at a time when it would not have been possible to have called such an organization by a more appropriate name, and this also led to confusion in the public mind as to its authority and responsibility. Its authority was broad, because the men who composed it were men of strong personality and understanding and made their powers broad enough to fill the gap that was necessary to be filled between the Army and Navy and the industrial life of the country, and at this writing we are almost too close to the achievements of the Council of National Defense to appreciate the importance and magnitude of the work which it so successfully accomplished.

It is also very difficult to realize that by the act of Secretary Daniels in creating the Naval Consulting Board there should be set in motion such a tremendous campaign for the preparing of the country for war which would result in the formation of a body such as the Council of National Defense, the Advisory Commission of which was composed of such men as Howard E. Coffin, vice president of the Hudson Motor Car Co.; Daniel Willard, president of the Baltimore & Ohio Railroad; Julius Rosenwald, president of Sears, Roebuck Co.; Bernard M. Baruch, banker; Dr. Hollis Godfrey, president of the Drexel Institute; Samuel Gompers, president of the American Federation of Labor; and Dr. Franklin Martin, secretary-general of the American College of Surgeons, Chicago, representing business, transportation, banking, science, labor, and medicine, the result being that the civilian structure which was evolved by the United States for the conduct of the war, and which in realty was the War Cabinet of the administration, should be determined in its characteristic features by the industrial preparedness campaign of the Naval Consulting Board.

Had the campaign not been conducted it is not at all unlikely that other means, probably founded on political selection, would have been evolved for doing this very important work.

Many people during the war were impressed with the fact that politicians had very little to do with the handling of the immense amount of business transacted by the United States Government, and when one considers the character of the men composing the Council of National Defense, their occupations and connections, it is readily understood.

CHAPTER III.

Part 1.

FUEL OIL.

As pointed out in the chapter on "Organization," the Naval Consulting Board consisted of two representatives from each of the large engineering societies of the United States. Some of them were executives in the largest industrial organizations in the country, others were inventors, others scientists; but they all had a wide acquaintanceship in scientific, engineering, and business circles, and it might not be unfair to say that they were capable of mobilizing at any time all of the important engineering and scientific information in regard to any particular industrial matter on which they might seek information.

This power to coordinate and make available for the Navy Department all engineering, scientific, and business information in regard to the fuel-oil industry was well exemplified at a meeting in, the spring of 1916. The Navy Department at that time was vitally interested in the fuel-oil situation in the United States in its relation to the United States Navy, particularly in regard to the policy which the Naval Establishment should follow in regard to the burning of fuel oil on the battleships and some pending legislation in Congress in regard to the unpatented lands in the naval petroleum reserves of the United States. This legislation, if enacted, would practically abolish the naval petroleum reserves, and the Navy would be forced to decide whether it should continue to build oil-burning vessels which would depend, for their usefulness to country in the time of danger, upon an uncertain supply of oil, or build fuel-burning vessels which would be admittedly inferior to those of the nation that had a good control of the supply of oil.

The conference was initiated in the following manner: Early in 1916 the Naval Consulting Board received a communication from Rear Admiral John R. Edwards, chairman of the "Naval Oil Fuel Board," asking for the members' cooperation in obtaining data on fuel oil.

A special Committee on Fuel and Fuel Handling was appointed to cooperate. Mr. Spencer Miller, a member of the Naval Consulting Board, was made chairman of the committee with authority to appoint others to serve on it. The other members of the committee were Messrs. Addicks, Baekeland, Hunt, Maxim, Richards, Robbins, Thayer, Whitney, and Webster.

The members of the Naval Fuel Oil Board were Rear Admiral John R. Edwards (chairman), Lieut. Commander John Halligan, jr., Lieut. Commander J. O. Richardson, Lieut. O. D. Conger, and Lieut. F. W. Milner, all of the Unitel States Navy.

The naval officers had prepared a questionnaire inquiring into the supply of fuel oil, the storage of fuel oil, the transportation of fuel oil, pipe lines for fuel oil, combustion of fuel oil under boilers, chemists on fuel oil, the storage on a warship, the attitude of the British Admiralty, specifications of purchase, and commercial consumers.

In general, the object of the questionnaire was to assist the Navy Department in the solution of the many perplexing problems arising in connection with the ever-increasing employment of fuel oil on battleships, cruisers, dreadnaughts, and destroyers, and the situation was such as to warrant any patriotic citizen to lend such information as he might possess to the attainment of this object.

In all, there were some 85 questions thus prepared and immediate answers to which were valuable, if not indispensable, to the Naval Establishment.

The Naval Consulting Board proposed a joint conference, to be held in New York, where there resided a number of oil-fuel specialists who could be immediately called together for an all-day conference if held in the city of New York. On less than a week's notice, a conference was held Saturday, July 1, 1916, in the Engineering Building, 29 West Thirty-ninth Street, New York. At this conference, at which Mr. Spencer Miller presided, there were present:

Rear Admiral John R. Edwards, Lieut. Commander John Halligan, jr., Lieut. Commander J. O. Richardson, Lieut. O. D. Conger, Lieut. F. W. Milner, members Naval Fuel Oil Board; Forrest M. Towl, Dr. Leonard Waldo, W. N. Best, Dr. D. S. Jacobus, H. M. Storey, Walter McFarland, Philip W. Henry, Ernest Peabody, Harvey Bell, invited guests; Lawrence Addicks, Dr. L. H. Baekeland, A. M. Hunt, Hudson Maxim, Thomas Robins, B. B. Thayer, Dr. W. R. Whitney. Spencer Miller, Dr. A. G. Webster, members Naval Consulting Board.

Every one of the invited guests was an acknowledged expert and master of at least one, if not several, phases of the oil-fuel problems, as outlined in the group of questions, and each one of these men invited was personally known and nominated by some member of the Naval Consulting Board.

It was possible to get these men to attend the conference, owing to the fact that members of the Naval Consulting Board, in their professional and business connections in civil life, had come in contact with these men, and this enabled them to select men of the caliber and distinction of those invited. The success of the conference was largely due to the information which these men contributed to the conference. Many members of the Naval Consulting Board itself were also specialists in some phases of the problems.

Among the men present were some who, if consulted in regard to a fuel-oil question, would no doubt require a large retainer before considering the matter. They gave to this conference the most valuable information without any expectation of compensation and purely out of consideration and patriotism.

Prior to the conference all the books from the Engineering Library bearing on this question were placed in the conference room for review and examination, and the American Society of Mechanical Engineers donated its board room for the use of the conference.

The history leading up to this conference was as follows:

In 1911 the first battleships to contain an exclusively oil-fuel installation were authorized, and this was in some respects a very radical departure and was thought by those in the Navy that, owing to the increased demand for gasoline and other volatile components of petroleum, within a few years the bulk of the fuel-oil supply for the Navy would be a viscous and heavy product, and the Navy wa particularly interested in the question of an assured fuel-oil supply with the proper characteristics. They also were particularly interested in questions of transportation and storage, oil tankers, and supply ships necessary to meet the demands of the Navy and the amount of fuel-oil storage capacity to supply the Navy.

It was estimated that when the three-year building program at that time authorized by Congress for the increase in the Navy, there would be required for naval use millions of barrels of fuel oil annually during peace and about three times that in the event of war.

All the proposed new ships were oil burners and the securing of an adequate supply of oil for the future was a matter of prime importance to the Navy. The superiority of oil-burning ships was so great that the Navy Department desired to build oil-burning battleships, but were somewhat perturbed over the fear of a failure of the supply of fuel oil.

In September, 1912, the President, under authority of an act of Congress (36 Stat., 847), set aside from the already withdrawn area of public lands in California, a definite area to be known as the "Naval Petroleum Reserve No. 1"; in December, 1912, the second reserve (No. 2) in California, and in April, 1915, No. 3, in Wyoming, were similarly created by the President. The orders creating these naval petroleum reserves stated that the area "shall be held for the exclusive use or benefit of the United States Navy."

It was the intention to hold these areas, which could be wisely conserved in reserve and not utilize their oil content until the shortage of domestic production or the increased price of fuel rendered it advisable. These reserves were designed to serve as an assurance against the posibility of having a large fleet of exclusively oil-burning warships with no oil available.

At this time many of the students of the petroleum reserves of the United States had predicted an early decline in the yield of petroleum and had estimated that the supply in the ground would last only approximately 22 years.

Among the important questions taken up at the conference was the question of desirability of the Navy to undertake production of its own fuel and lubricating oils as well as gasoline. The question of the cost to the Government of producing 5,000,000 barrels of fuel oil was discussed, and the matter turned on whether the production of crude petroleum in the United States would reach its maximum in the course of the next few years. In coming to a conclusion in this matter it was necessary to take into consideration prospective fields in Alaska, Arizona, Caribbean Sea, and Hawaiian Islands, as well as the west coast of Mexico, Central America, South America, and an investigation of the stocks of fuel oils carried in foreign ports, together with a detailed outline of existing domestic facilities, including the location of tankage, pipe lines, maximum and minimum quantities of oil on hand, sources of supply, docks and depth of water alongside, etc.

One of the important points taken into consideration was the question of storage of fuel oil, and its searching power, and whether liquid fuel could be stored beneath the ground in large quantities in the United States. An understanding of this matter necessarily took into consideration the construction of underground concrete storage tanks, the effect of heat and cold on a concrete construction, and the proportionate constituent parts that would be used in such concrete, the safety of the tanks, and the effect of explosions of dynamite on them, as well as the covering of the tanks with clay, sand, broken rock, or sand loam. The names of those firms in the United States that had had the most extended experience in oil-tank construction and the latest designs of storage tanks and pumping equipment were also investigated.

Another interesting phase of the discussion was the determination of number of oil-tank cars in the United States, and the average capacity of each car, as well as the number of cars that were being built.

Under marine transportation were considered the number of oil barges in the United States, with their average carrying capacity, and the trend of construction toward craft of larger capacity, and the consideration of sailing ships carrying oil in bulk.

Under this general head of transportation of fuel oil was also considered the question of extending pipe lines from Point Breeze, Philadelphia, to the League Island Navy Yard, and from the nearest California pipe lines to the Mare Island Navy Yard. The question of pumping oil from the Tampico fields to some harbor on the west coast of Mexico was also considered. The safest method for cleaning oil pipes, the building of pumps for heavy crude oil, and artificial means for making fuel oil fluid, were also discussed.

The conference went into the question of combustion and discussed furnaces and smokestacks and the desirability of placing baffle plates in a water-tube boiler, also the action of sulphur in fuel oil on the tubes, the difficulty of efficiently operating oil burners and the necessity for providing additional combustion-chamber space for oil fuel beyond that which seemed adequate for coal-burning boilers, the type of boiler used in heavy fighting ships equipped with an exclusively oil-burning installation. The question of whether the lower tubes on Babcock & Wilcox boilers would sag when the boilers are forced for a continuous period was also discussed, as well as how high a flash point should be demanded by naval specifications.

Under the head of chemists on fuel oil was suggested the question of retaining a chemist on fuel oil who was particularly fitted to render this service to the board.

The storage of fuel oil on warships involved the consideration of the question of whether the Government should demand a higher flash point for oil that must be stored on battleships, and as to whether there was some safe chemical to clean tanks to remove the residuum from fuel oil, as well as the question of inspecting the double-bottom compartments of ships in which fuel oil is now stored on battleships, as well as the pumping of such oil from these compartments.

The specifications of the Navy Department for the purchase of fuel oil, and as to whether they were more safe than those for the merchant service, were gone into, and in considering this matter the nature of contracts which foreign Governments had for the supply of oil in this country were considered. Under this question of specifications, under which oil is produced, came a question of water contents, sulphur, asphaltum or sludge, and flash point, as well as other matters.

The discussions above outlined were taken down in shorthand and mimeographed copies made, which were sent to those interested, and the majority of the questions, as set forth in the copy of the discussions, were answered to the satisfaction of the Naval Fuel Oil Board.

On August 14 and 15, 1916, a second joint meeting of the Naval Fuel Oil Board and Fuel Oil Committee of the Naval Consulting Board was held in Newport, R. I., and the committee visited and inspected the oil-burning battleships *Oklahoma* and *Navada.* A third meeting was held on the 6th of December in New York. The committee gave several months' study to the special problem relating to the future supply of fuel oil for the Navy and reached the following conclusion:

First. The use of fuel oil enables the Navy Department to produce war vessels of a marked superiority in type. The projected battle cruisers, for example, could not be reproduced if required to use coal, nor could they be remodeled for burning coal, even at comparatively prohibitive cost, without seriously curtailing their military value.

Second. It is the unanimous opinion, therefore, of your committee that the requirements of national defense demand that the Nation hold with unassailable title reserves of oil land within its own borders, located with reference to economical transportation, and containing sufficient oil to meet the requirements of our ever-enlarging Navy for a period of not less than 50 years.

Third. The best estimate at hand, that of the United States Geological Survey, respecting the probable remaining supply of petroleum underground within the United States is 7,629 million barrels. The marketed production of petroleum within the United States in the year 1915 was 281,104,104 barrels. A simple calculation will show that should the consumption of oil remain fixed the estimated available supply will last only 28 years. While forests cut down can be reproduced in time, petroleum taken from the ground and consumed is forever gone.

Your committee is well aware of the fact that great quantities of fuel oil are to-day imported from Mexico for industrial uses and that the Mexican oil fields are probably the most extensive deposits of oil anywhere in the Western Hemisphere, if not in the world, but it believes that as a means of national defense such oil supply could not and should not be depended upon in the event of war. To-day Great Britain renews her supply of oil fuel from Mexico, and is assured thereof only so long as she maintains undisputed control of the seas.

For the use of our Navy it is now estimated that there will be an annual consumption in time of peace of quantities increasing from 842,000 barrels during the present fiscal year to 10,000,000 barrels annually in 1927. In time of war this consumption will be increased at least threefold. That is to say, we must face the possibility of a consumption in war time of not less than 30,000,000 barrels per annum. Nor does this take any account of oil fuel for aircraft or for industrial processes associated with national defense.

Your committee has given full consideration to the possibility of diverting from these industries sufficient oil to meet the demands of the Navy in time of war, but has reached the conclusion that this might of itself cripple industrial establishments upon which the Nation must depend for munitions of war.

Your committee, in view of the foregoing, believes that the representatives of our Nation in Congress now assembled have before them at present a question of supreme importance to the national defense, in that certain legislation is pending which imperils the present oil reserves of the Navy, and therefore your committee has prepared the following resolutions which it offers to the Naval Consulting Board with a recommendation for their adoption.

Since the time of the conference in 1916 several large oil fields have been discovered, which have altered the situation which confronted the conference on July 1, 1916.

After thorough consideration of the matter, the following resolution was adopted by the committee of the Naval Consulting Board which arranged the conference and it was presented to the board for adoption:

Whereas the Navy Department, after years of study and consideration, has definitely committed itself to the use of oil fuel on our naval vessels on account of its superior military advantages; and

Whereas the permanence and continuity of such fuel supply must be assured both for time of peace and of war; and

Whereas legislation is now pending in Congress which jeopardizes the integrity of naval petroleum reserves heretofore established for the above purpose; and

Whereas action by Congress adverse to the Navy Department's interests in these reserves will constitute a precedent for future actions, and make any reserve whatever uncertain and liable to diversion: Therefore be it

Resolved, That the Naval Consulting Board, the official civilian advisory board of the Navy, composed of members of 11 national engineering and scientific societies, is convinced that any legislation which may divert from the Navy any portions of its reserves will seriously weaken the Navy and imperil the national defense. The Naval Consulting Board, therefore, urges upon the Nation and its representatives in Congress to permit no steps to be taken that will impair the integrity of the existing naval petroleum reserves.

The Naval Consulting Board commends the recent action of the Secretary of the Interior in recommending the creation of additional naval reserves in Colorado, Utah, and Wyoming on lands which have prospective value for oil production.

The Naval Consulting Board, however, does not believe that these recommended reserves can be considered as substitutes for existing reserves.

SPENCER MILLER, *Chairman.*
HUDSON MAXIM,
ARTHUR GORDON WEBSTER.
BENJAMIN B. THAYER.
JOSEPH W. RICHARDS.
A. M. HUNT.
L. H. BAEKELAND.
THOMAS ROBINS.
LAWRENCE ADDICKS.
W. R. WHITNEY.

As a result of this investigation, Secretary Daniels stated that the Navy Department would maintain its legal rights, whatever they might be, to the unpatented lands in the naval oil reserves, and the legislation which was designed to take these lands away from the Navy Department was never passed.

Secretary Daniels wrote to Mr. Spencer Miller the following letter:

NAVY DEPARTMENT,
Washington, December 22, 1916.

Mr. SPENCER MILLER,
Chairman Fuel and Fuel Handling Committee,
Naval Consulting Board, 96 Liberty Street, New York, N. Y.

MY DEAR MR. MILLER: In acknowledging the receipt of the report of your committee of the Naval Consulting Board on the subject of the supply of fuel oil for the Navy, under date of December 9, 1916, I desire to thank you, and through you the members of the committee for the splendid assistance that has been rendered the Navy in this important matter.

Through the efforts of you gentlemen there was placed at the disposal of the Naval Fuel Oil Board information on the subject of petroleum which could not have been secured otherwise. The results obtained in this instance exemplify the great good that can come to the Navy through the cooperation of distinguished civilians actuated by the patriotism and unselfish devotion that has been shown by the members of your committee.

Cordially, yours,

JOSEPHUS DANIELS,
Secretary of the Navy.

It should be noted that the meeting was held on short notice, in order that the members of the board and invited experts might be privileged to give their experience to the United States Navy at the earliest possible moment.

No doubt results of the conference above mentioned reenforced Secretary Daniels in his position and made the Senate virtually abandon plans for any legislation in regard to leasing potash, oil, and phosphate lands from the Federal Government and refusing to agree to any remedial legislation affecting claimants to unpatented lands within the naval petroleum reserves.

CHAPTER III.

PART 2.

NEW NAVAL STATION ON PACIFIC COAST.

In accordance with the naval appropriation bill passed in August, 1916, by which the President was authorized to appoint a commission of five officers of the Navy to investigate and report as to the necessity, desirability, and advisability of establishing an additional naval station on the Pacific coast of the United States, the following commission was appointed:

Rear Admiral J. M. Helm, U. S. Navy; Chief Constructor W. L. Capps, U. S. Navy; Chief Engineer H. H. Rousseau, U. S. Navy; Capt. G. W. McElroy, U. S. Navy; and Commander C. L. Hussey, U. S. Navy.

Below is an extract from the naval appropriation bill:

The President is hereby authorized to appoint a commission of five officers of the Navy not below the rank of commander to investigate and report at the beginning of the next regular session of Congress if practicable, and if not, as soon thereafter as practicable, as to the necessity, desirability, and advisability of establishing an additional navy yard or naval station on the Pacific coast of the United States. And if such a navy yard or naval station be recommended as necessary and advisable, said report shall designate the most suitable site and the estimated cost thereof, together with a detailed statement of the reasons for such designation and the nature and scope of the activities for naval purposes of such yard or station. In arriving at such designation the commission shall take into consideration all strategical and other military considerations as well as all industrial elements necessary for the economical and successful operation of such a yard or station, including local conditions as to labor and material. Said report shall also contain an estimated cost of the necessary buildings, shops, piers, sea walls, and equipment of said yard or station, together with the estimated annual cost of maintenance thereof.

Said commission shall also investigate and report upon the necessity, desirability, and advisability of improving existing or establishing an additional navy yard or naval station on the Atlantic coast south of Cape Hatteras or on or near the United States coast of the Gulf of Mexico or in the Caribbean Sea of a character adequate for the proper naval defense of that portion of the country. Said report shall contain all the information of like character as directed in the preceding paragraph relating to the investigation and report as to the Pacific coast.

Said commission shall also investigate and report as to the necessity, desirability, and advisability of establishing submarine and aviation bases on the

Atlantic, Gulf of Mexico, and Pacific coasts and other possessions of the United States, and as to the cost and location thereof:

Provided, That the sum of $10,000 is hereby appropriated to defray the expenses of said commission, including drafting, technical, and clerical assistance in the Navy Department or elsewhere.

Said commission shall also investigate and report as to the necessity, desirability, and advisability of abolishing any existing navy yard or naval station, and if such action is recommended, to report fully the reasons therefor and the advantages to be obtained thereby.

Rear Admiral Helm then wrote the following letter to Mr. Thomas Robins, secretary of the Naval Consulting Board, and this started in motion the machinery for investigating the necessity and desirability for establishing an additional naval station on the Pacific coast:

NAVY DEPARTMENT,
COMMISSION ON NAVY YARDS AND NAVAL STATIONS,
Washington, D. C., 25 October, 1916.

Mr. THOMAS ROBINS,
Secretary Naval Consulting Board,
13 Park Row, New York City.

DEAR SIR: The Commission on Navy Yards and Naval Stations, appointed by direction of the President to carry out certain provisions in the recent naval appropriation bill, as quoted in the inclosure herewith, requests the assistance of the Naval Consulting Board in obtaining information relative to commercial facilities and resources that would be available to the Navy in time of war.

The commission requires complete information in regard to available facilities and resources that, for war operations, might be utilized to advantage by the Naval Establishment, afloat and ashore, along the entire Atlantic, Gulf, and Pacific coasts of the United States. The commission is not familiar with the character of the information obtained by the Naval Consulting Board and now available.

In order that it may understand the general scope and character of the available information, the commission requests that data for one section of the coast be now furnished; for practical reasons prefers that the Pacific coast, from San Diego to Puget Sound, be considered first.

The information desired is as to existing and projected commercial facilities and resources on the continental coast of the United States, or so near the coast as to be readily available through water or land transportation:

(*a*) Dry docks—graving, floating, marine railways.

(*b*) Berthing facilities available for naval vessels at commercial wharves, piers, and quays, including statement as to depth of water at each.

(*c*) Shipbuilding plants, machine shops, etc., capable of extensive or minor repairs to naval vessels, including small craft, and to aircraft, with a statement of the number of mechanics at each establishment, specifying trades where practicable.

(*d*) Fuel suitable for Navy use—coal; oil, both heavy and Diesel engine; gasoline. Storage capacity for each of the above; average amount of each on hand; annual consumption of each; facilities for delivery; time of delivery after order received; rate of delivery for 8-hour day and for 24 hours and continuously thereafter; cost of fuel; cost of delivery.

Owing to the limited time allowed to conduct the investigations and submit report the commission would appreciate receiving the data in parts, as it may be prepared. When acknowledging receipt of this communication, would you kindly state when the first of the data may be expected.

Respectfully,

J. M. HELM,
Rear Admiral, United States Navy,
Senior Member of Commission.

The industrial preparedness campaign of the Naval Consulting Board had brought into existence, as associate members of the Naval Consulting Board, men who were particularly qualified to get the information which was desired by the Navy Department, and they made comprehensive reports to the Navy Department that were of great value.

CHAPTER IV.

SPECIAL PROBLEMS COMMITTEE.

On the 3d day of February, 1917, Count Bernstorff, German ambassador to the United States, was given his passports by President Woodrow Wilson, and it was felt by members of the Naval Consulting Board that some further action to curb the submarine menace should be immediately taken. Mr. Lawrence Addicks, member of the Naval Consulting Board, was particularly impressed with the situation, and in the absence of the chairman and secretary of the Naval Consulting Board, gathered together the available members of the board a day or two after the Bernstorff incident to determine what should be done. At this meeting it was decided to call a meeting of the board on due notice to consider the matter.

At a meeting of the board called on February 10, 1917, a plan was laid before it to organize a committee to be known as the "Special Problems Committee." Under the previous arrangement of the board, there was a Committee on Submarines, a Committee on Torpedoes, and a Committee on Explosives, etc., with the result that experiments or inventions connected with the single issue of the submarine menace were scattered through various committees of the board, and there was no real coordination. The committee was organized at this meeting and the name "Special Problems" was given it to avoid conflicting with the other committees; but the intention was to turn over to it all matters relating to the submarine menace, regardless of their nature.

Mr. Lawrence Addicks was made chairman of this committee, the other members of which were Dr. Miller Reese Hutchison, Benjamin G. Lamme, Matthew B. Sellers, Elmer A. Sperry, Dr. A. G. Webster, Dr. W. R. Whitney, and Mr. A. M. Hunt.

The most promising lines of attack on the submarine were classified and one group was assigned to each member:

Dr. Whitney was given detection by sound; Mr. Lamme, detection by magnetic, electromagnetic, and electrical means; Mr. Sellers, detection by sight; Mr. Sperry, underwater searchlight; Dr. Hutchison, bombing from aeroplanes; Mr. Hunt, protection of vessels by nets; and Dr. Webster, miscellaneous special problems.

A meeting of the committee was called at once in Washington to go over all the German matter in the hands of the Intelligence Department. Admiral Oliver turned over to the committee without reserve all the Navy files and reports of the attachés abroad. Very little that was of direct use was obtained, however, the real fact of the matter being that very little had been accomplished in the way of dealing with the submarine.

The first investigations to determine the value and limitations of listening devices were made off Pensacola, Fla., by the United States naval submarine force during January, February, and March, 1917. The apparatus used during these tests was that supplied by the Submarine Signal Co. as a part of this company's standard under-water signaling apparatus.

At the suggestion of Dr. W. R. Whitney, of the General Electric Co., Mr. H. J. W. Fay, of the Submarine Signal Co., appeared at a meeting of the Naval Consulting Board in New York on February 17, 1917, and explained the art of submarine signaling as he knew it at that time, and suggested certain lines of investigation which he believed would be profitable in the adaptation of signaling devices for detection of submarines. As a result of the appearance of Mr. Fay before the board, a Special Problems Committee of the Naval Consulting Board visited Boston on February 23, 1917, and witnessed a demonstration of the devices then manufactured by the Submarine Signal Co. During the visit of this committee the advisability of obtaining a station at which experimental apparatus could be tested was discussed, and the officials of the Submarine Signal Co. stated that the company would probably be willing to provide such a station and its equipment, and to assist in carrying out any experimental work which was deemed necessary by the Navy Department. On March 20, 1917, Mr. Fay, of the Submarine Signal Co., conferred with the Chief of Bureau of Steam Engineering regarding the establishment of an experimental station at Nahant, Mass. At this time, the chief of the bureau approved the plan to establish such a station and suggested that the General Electric Co. and the Western Electric Co. be invited to cooperate with the Submarine Signal Co. in work at this station. In April, 1917, the station was completed and the Submarine Signal Co. and the General Electric Co. began experimental work. Early in May, 1917, the Western Electric Co. joined the other two companies in this work. The Submarine Signal Co. furnished the building and the oscillators and some three cables which were run out to sea. oscillators being located at three different points with the idea of getting definite locations of objects by a sort of triangulation.

The Special Problems Committee being thus formed, it seemed desirable to widen the field from which information relative to the submarine menace might be had, and therefore there was arranged what was known as the "Submarine defense conference"[1] of the Committee

[1] For a list of those invited to attend the conference, see Appendix, p. 235-236.

of Special Problems of the Naval Consulting Board, held in the Engineering Society's Building at New York on March 3, 1917. Each member of the board was called on to nominate 10 men for each of whom he could vouch as to his loyalty, and who, in his opinion, had special knowledge of some department of science which could be applied to the submarine question. From a very large number of names suggested, the Committee on Special Problems selected 35 men. This list was then submitted to the Secretary of the Navy for criticism, and it was understood that the proceedings of the conference would be confidential, and that no other outsiders would be admitted, on which basis the Navy would present full information and answer all questions.

Rear Admiral William S. Sims, president of the Naval War College, was asked to present the general problem of defense against the submarine. This selection was particularly fortunate, in view of the fact that Admiral Sims a few days later was sent abroad as commander in chief of the United States Navy operating in the war zone.

Capt. J. K. Robison, who was then inspector of ordnance at the Newport Torpedo Station, was asked to give a talk on the torpedo; and Commander Yates Sterling, jr., in charge of the submarine base at New London, was asked to talk on the submarines.

The following somewhat detailed account of the conference, showing the questions that were in the minds of those attending it and the information developed, are set forth in order that a true picture as near as possible may be given of the problem of the submarine menace as it presented itself to the Naval Consulting Board and its invited guests at the time of the conference on March 3, 1917.

Before the discussions took place an outline of the subjects to be discussed was prepared and the subject analyzed so that discussion would be facilitated.

The subject was treated under three general headings: Detection of submarines, annihilation of submarine after detection, and the defeat of the torpedo.

Under the general head of detection of submarines was considered first the possibility of detection by ships or shore lookouts. This involved the question of the best type of marine glasses that were available, the available stock and possible supply of such glasses, and the possibility of the development of any special means for the detection of the wake of the submarine, consisting of a white streak or oil globules on the surface of the water. It was noted that old whalers can readily detect conditions on the water which are imperceptible to the average observer, and that some wake is apparent even when a submarine is running totally submerged on the energy of her batteries.

Suggestions were also asked in regard to the detection of submarines by aeroplane scouts, and it was noted that the success of this method apparently depended upon the condition of the sea, color of the bottom, and clearness of the water, and that the average conditions along much of our Atlantic coast were not favorable.

The most important method of detection, however, was that discussed under the heading of underwater observation; and under magnetic effects was considered the possibility of planting large compasses corrected for the earth's magnetism and in brass cases, on the bed of a harbor or channel, and by suitable indicating devices electrically connected to the shore or locally to an alarm buoy, give warning of an approaching submarine. The question was raised as to whether such a device could be used on shipboard where masses of iron would have to be corrected for.

A discussion of electrical conductivity effects was also considered, and the question was asked as to what could be done in the way of utilizing the change of conductance in a given block of sea water by the entrance therein of a submarine, and as to whether suitable measuring instruments and power supply would be possible on shipboard. A question was asked as to whether such a scheme would introduce serious problems of electrolytic corrosion.

Under optical devices the following questions were asked: How far can a beam of light from the most powerful source now known penetrate under water, and could reflected light rays be made the basis of any system of detection? Could some means other than the eye be employed? Would not such a scheme indicate your own whereabouts to the submarine?

Under the general head of sound, the following questions were asked: What is the source of the characteristic noises made by a submarine in motion when submerged, by its commutator, propeller, and bow displacement? Can these noises be suppressed so that sound-detecting devices would become valueless? How far can the noises made by existing submarines be heard by microphones or oscillators? How closely can such a system locate a submarine by triangulation from a shore-base line, and is there any hope of reasonable triangulation from the shore-base line available on a ship? Can anyone suggest any sort of a noise filter to exclude sounds due to noise of motion of ships on which listening device is placed? In case submarines become noiseless what are the limitations upon sending out sound waves and listening for the echo? Are there any other types of apparatus available besides the microphone and the oscillator, and can anyone suggest other lines of attack on the problem of detection?

Under the general heading of annihilation of submarine after detection, the following questions were asked: What is the effective radius of action of an underwater explosion in starting the seams or breaking the batteries of a submarine? (The Navy has confidential data based on experiments to determine this point, but the question is suggested in case any present may have information from European sources.) At what depth is a bomb most effective? Can a shell be designed which will enter the water at such an angle when aimed at a partially submerged submarine so as to continue on its flight under water? (The shape of the nose of a shell has much to do with its ricocheting.) Can a net be devised which will readily ensnare upon contact? (Nets are of small value unless watched. Adequate watching is very difficult in heavy or foggy weather.) What automatic signal devices are available to locate a submarine which runs into a net but is able to back out unharmed? (A submarine drags a net at considerable speed before its momentum is absorbed.) Is it possible to anchor devices which would mechanically damage a submarine but be harmless to surface craft owing to location by buoy? What developments are possible analogous to spreading oil upon the water in order to cloud the periscope when emerging?

Under the general head of defeat of the torpedo were asked the following questions: Is there any way in which torpedo-net defense can be applied to a moving ship? (Nets must be double to offset net-cutting devices on torpedo; they take a great deal of time and labor to rig out and in; they would greatly retard the speed of a moving ship and almost surely foul the propeller.) Can the idea of hanging out plate-iron false work be made practical, and would a false work, say, 20 feet away from the side of a ship save it from torpedo destruction, or would the explosion be transmitted to the ship itself through the water? Would a net-cutting bomb go through any reasonable false work? Could any net or false-work device be mounted to drop in time to encounter an approaching torpedo while being out of the way when on safe ground? Would heavy false work tow true or would it slew out of place when ship was in motion and either defeat its own purpose or damage the ship itself? Can the oscillator, etc., be successfully applied to a ship as a listening device which would warn of the approach and bearing of a torpedo which had been launched against it? Could some form of countermine be sent against the torpedo from the ship? (This might be a bomb similar to those used by aeroplanes against submarines.) Would such a bomb have a reasonable radius of action in damaging the torpedo? What are the weak spots in a torpedo which could be attacked? Could any sort of periodic vibration in the water be made to act upon the depth diaphragm so as to send the torpedo off its normal horizontal course? The subject of maneuvering was also discussed.

Perhaps the most important result of this conference and discussion was that there was mobilized in this meeting the special knowledge on the subject which was available, to coordinate and bring to one group of men all of the problems relating to the submarine menace. The civilians at this meeting got their first real understanding as to the scope and limitations of the problems they were trying to deal with. The naval officers received benefit from the cross-fertilization of ideas with the civilian scientists, inventors, and engineers present as to the possible lines of attack from more or less unconsidered sources which could be made.

It developed that detection of the submarine was essential to submarine destruction. Without means of detection, the handling of submarines is without the first essential necessary for their destruction.

At this submarine defense conference there was developed the following information in regard to submarines, which was true at that time: First, that they have a speed of from 14 to 15 knots above the water, and below the water perhaps 8 to 10 knots; that the submarine has a very limited radius under the water; when she goes down she puts her engine out of commission and runs on electric batteries; when these are exhausted she must come to the surface to recharge them; while she is underneath she can not remain still, but must move fast enough for her traverse rudders to keep her in a condition of equilibrium; when she is submerged she can see nothing at all, but she is not deaf; submarines can not submerge more than 200 feet safely; for some reason or other the periscope range of vision is small; that those in a submarine can not see very far from a periscope when the submarine is submerged; the periscope is almost useless at night.

There are two kinds of submarines—coast-defense submarines, supposed to be used in a short radius and not going very far from home; seagoing submarines from 800 tons up, with a speed of 15 knots on the surface and probably about 10 knots submerged.

When the submarine is on the surface it has no means of protection, and it can not stand a fight with another vessel. An ordinary fishing vessel can outfight it, because a submarine can not stand being punctured, as it prevents her going down again. It is very difficult to hit a submarine; she is not very much out of the water, and projectile will not penetrate the water at all, especially at a short range, when firing at a submarine. As a submarine can not afford to be hit even once, therefore any ship in her neighborhood that has guns will force her to go down. If a merchantman is armed a submarine knows she can not come to the surface, so she remains submerged with the periscope out and fires a torpedo when the merchantman goes by. A torpedo can be fired from a submarine either when it is submerged or on the surface. The range of a torpedo carried by a submarine is not more than 1,000 to 2,000 yards. The submarine can not expect to hit a vessel at very great range. The torpedo has a very heavy war head.

That there is certain signal apparatus on submarines by which it can hear the vibrations of the engine or propeller of a ship; that all naval authorities would like to know a great deal more about these vibrations; that aeroplanes can detect the presence of a submarine by the trail on the surface of the water when the sun is favorable, if the submarine is going at full speed.

A submarine from the bottom of the hull to the top of the periscope is about 40 to 42 feet, therefore submarines must stay in at least 50 to 60 feet of water. For this reason it is very fortunate for the Allies that the English Channel is so narrow and shallow. If it were 150 miles wide and a couple of miles deep, the war might have a different history. The English Channel is constantly patrolled and every submarine is reported and plotted on a sectional map.

That it would be of inestimable value if there were any means by which a torpedo could be turned aside or blown up without requiring an impossible degree of vigilance and skill on the part of the people on a merchant vessel. Gunfire against a torpedo is almost impossible for one reason, because visibility from the inside of the turret is not very great. That you can not steam very well with a net which is down, although they can be used by ships at anchor, and were so used until a war head was invented which blows holes through the net, also scissors have been arranged to cut nets, and a bomb had been devised to place at the end of a torpedo to blow holes in the net.

That when a vessel is going along at a certain speed which is calculated to be so many knots and a course in such direction, a torpedo is fired so as to meet the vessel at a certain point ahead on its course, and no way is known of stopping it; that the track of the torpedo can be seen with great distinctness except when the sun happens to be in the wrong direction, and probably in a smooth sea a distance of some 2,000 to 3,000 yards.

The German submarines are said to have sufficient storage-battery plates to run submerged at 10 knots for 3 hours, at 8 knots for 12 hours, at 4 knots for 36 hours, at 1 knot for 72 hours. Therefore some German submarines can go down and stay out of sight for three days, the result being that the task of hunting it becomes almost hopeless.

A torpedo for purposes of destruction can be divided into three parts: The business end full of trinitrotoluol; the compressed-air tank, which is the source of power and which is used in all types of torpedoes; and the engines that run it. There are two rudders on it, one horizontal and one vertical, that run just forward of the propellers. On the end of a torpedo is a concussion detonator. When the torpedo strikes a target the discharge is exploded by concussion, but the torpedo also explodes when it stops or when deviated from its course.

The compressed-air charge is a measure of the total power that can be used, which can be used down to a pressure of about 400 pounds to the square inch.

The machinery of a torpedo is run at a constant speed by using a radius available between the compressed-air tank and the engine itself. The Germans used a 3-cylinder engine to drive a torpedo. A torpedo has to be just about the same weight as the water that it displaces. The bigger the diameter of the torpedo the more power it can give. Customary diameters are 18 to 21 inches, or 45 to 55 centimeters.

The problem in regard to torpedoes is: First, how are we going to keep it from doing what it is trying to do? Secondly, how are we going to keep it from striking entirely?

A torpedo probably would not do much damage if it is exploded as close as 50 feet distance from the ship, but it might start a few seams; 100 feet away it would not do any damage. The gyroscope of the torpedo regulates its course; it is as delicate as a watch and its bearings have to be just about right.

It was developed that the Germans were doing everything possible to reduce the sounds emanating from a submarine, and therefore the problem seemed to be to get a faint sound detector of exceeding delicacy, together with some method of determining the direction from which it came and the distance it had traveled from the submarine in making it.

The present state of the development of the arts in the other subjects which were discussed at the meeting became known to all of the men present; and as a result it served as a starting point for work on the development of devices in the arts discussed.

The Special Problems Committee of the Naval Consulting Board decided that the most promising line of attack on the submarine menace was development of listening devices.

On February 28, 1917, the Submarine Signal Co. wrote a letter to Mr. Lawrence Addicks in regard to the starting of a station at Nahant. At a meeting of the Naval Consulting Board on March 10, 1917, the board passed a resolution indorsing and appreciating their patriotic cooperation.

On April 7, 1917, the station was completed at Nahant, and active work at the station begun on antisubmarine devices.

Dr. W. R. Whitney took Dr. Irving Langmuir, Mr. C. E. Eveleth, and Dr. William D. Coolidge, of the General Electric Research Laboratory, of which Dr. Whitney was the head, down to Nahant, which was situated on the shore of Massachusetts Bay near the end of Nahant Peninsula.

Three or four small laboratories were put up there and the men who accompaned Dr. Whitney took to these laboratories the devices upon which they were working prior to that time, principally the pliatron for increasing and magnifying the audibility of sound. The pliatron was put on the Fessenden oscillator, which was a standard piece of apparatus built before the war, and used on vessels commonly throughout the war. An oscillator so equipped with a pliatron was placed on a tripod in the Bay of Nahant, and the passage of boats in the harbor and submarines were listened to.

Experiments were conducted to note the value of Fessenden oscillator without any amplification. With the amplifiers it was hoped to get, and they did get, very much better results. It was decided, however, that the oscillator was not the thing to use, because it was heavy and couldn't be installed on very small boats. It had a big motor generator as part of its equipment, and therefore work was immediately started to produce portable listening devices that could be put upon any boat.

In order to provide closer cooperation between each of the three companies working at Nahant and the Navy Department, the Secretary of the Navy called a conference in his office on May 9, 1917. This conference resulted in the appointment by the Secretary of a Special Board on Anti-Submarine Devices. On May 11, 1917, Admiral Grant was appointed senior member of this board and Commanders McDowell and Libbey were made members. A representative from each of the three interested companies and one from the National Research Council were appointed as advisory members. Immediately after this, the Nahant station was placed at the disposal of the Special Board on Anti-Submarine Devices and the desired cooperation was in this manner effected.

The National Research Council arranged for conferences which were held in Washington in the early part of June, 1917. Scientific representatives from England and France, representatives from the bureaus of the Navy Department and from the General Electric Co., Western Electric Co., and the Submarine Signal Co. were present. Sir Ernest Rutherford, the scientific representative from England, described certain experiments conducted abroad with Broca tubes, employing the binaural principle for the determination of direction. Subsequently, a group of scientists was organized by the National Research Council to carry on experiments at New London along the lines suggested from the conferences. Dr. Coolidge of the General Electric Co. repeated certain experiments in the Mohawk River with Broca tubes, employing the binaural principle for determining direction. The result of his experimental work in this connection was the invention of the C tube, which is an application of the binaural principle with modified forms of Broca tubes. A practical demonstration of the C tube was conducted in Boston Harbor in August, 1917. This was the first practical listening device developed in America during the war. The next device was developed at Nahant, and was known as the K tube. This device is an adaptation of the rotary compensator developed by Prof. Mason at New London, with microphones so as to enable the device to be towed several hundred feet astern of the listening vessel. Subsequently, the combined work at the Nahant station and at New London resulted in the development of the Y tube, Delta tube, OS tube, and OK tube. These devices are modified forms of the K tube, which were necessary for installations on different types of vessels. The work conducted at Nahant and at New London has at all times been under the direct supervision of the Navy Department.

On June 23, 1917, the Secretary of the Navy issued an order approving a plan to coordinate and organize the efforts of various groups considering submarine and antisubmarine devices and placed the whole under the special board mentioned above, of which Rear Admiral Grant was the senior member. (See copy of order in Appendix.) The civilian advisory members appointed on May 11, 1917, were Dr. W. R. Whitney, of the Naval Consulting Board; Mr. H. J. W. Fay, of the Submarine Signal Co.; Prof. R. A. Millikan, of the National Research Council (afterwards Lieut. Col. Millikan, U. S. R.); and Dr. F. B. Jewett, of the Western Electric Co.

Dr. Whitney was fortunate in having associated with him in the laboratory of the General Electric Co. at Schenectady, N. Y., Dr. Irving Langmuir and Mr. C. E. Eveleth, and that company gave its assistance. A great deal of production work was done by the General Electric Co. under contract.

Dr. Coolidge's discovery came about in this way: He was engaged in tying Broca tubes of different types to brass tubing, by means of rubber connectors, for operation under water, and was studying the effects of dimensions and material on the Broca tubes. He observed the fact that the listening was better, more sensitive, and was aperiodic under these conditions. He found that the rubber connectors alone were better on the listeners than the Broca tubes, and from that time on the efforts were directed toward the development of rubber listening devices. The longer the rubber connector was the better, until finally it was decided to drop off the Broca tubes and tie one end of the rubber tube with a string, and it was found that it worked better than it would with the Broca tubes. This experiment was done in the Mohawk River near the plant of the General Electric Co. at Schenectady, N. Y.

The so-called "C" tube was the tube of Dr. Coolidge, the "C" standing for the name of the man who developed it. It was sometimes called the "Sea" tube without anyone's correcting it. This system of naming the tubes by the first letter of the man's name who developed them was later abandoned.

Through the courtesy of the Navy Department permission has been given to publish information of certain listening devices developed under the cognizance of the Navy Department's direction at New London and Nahant, by the associated naval officers and scientists representing the special board, the Naval Consulting Board, the National Research Council, General Electric Co., Submarine Signal Co., and Western Electric Co.

The standard C tube is shown in photograph No. 74–9. It was made in three sizes, 15 feet long with one-half-inch brass tubing, 20 feet long with three-quarter-inch tubing, and 25 feet long with three-quarter-inch tubing. The total number of C tubes built was approximately 1,020.

The method of using the C tube is as follows:

After the ship has lost headway and the C tube put overboard, the observer seats himself and places the stethoscopes in his ears, care being taken to get the left tube in the left ear and the right tube in the right ear. He then listens without rotating the C tube until hearing a sound. To "obtain a fix" on this sound, if the sound appears to come from the left, turn the handwheel to the left, or in a counter-clockwise direction, until the sound appears to come from the right. Then turn to the right until the sound appears to come from the left again, and repeat this operation several times, making the amount of turning less each time until the sound seems to come from directly ahead, or is "centered." The scale reading will now give the direction of the source of sound in degrees from the ship's head. If this method is not followed and the wheel merely turned in either direction until the sound is centered, the scale reading is apt to be 180° from the true bearing.

In service, a boat equipped with this device advances in a series of rushes and stops. The usual time from stopping bell to starting bell, including time to take observations, is generally about 90 seconds and the accuracy of the angle usually closer than 5°. The range varies from 1,000 to 8,000 yards under different conditions.

After many further tests with C tubes, magnetophones, and microphones suspended from the rail and also from a submerged float at some distance from the ship, it was discovered that while a receding sound could be held longest by the most sensitive magnetophones or microphones, especially of the drifter type and nondirectional, the shorter range C tube almost invariably was the first to pick up a new sound. This showed that the binaural scheme of listening was of great advantage on account of the discriminating possibility on the part of the observer, due to his being able to apparently shift the sound by moving the device, as compared with the necessity of original recognition dependent upon detecting the rhythmic beat of the propeller, as in the case of the nondirectional device.

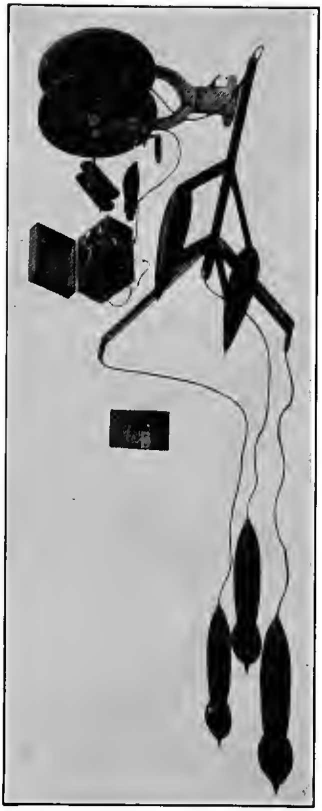
These tests clearly demonstrated the advantages of a device which would have sensitive microphone receivers arranged for binaural listening and located at some distance from the ship so as not to be affected by troublesome water noises, and every effort was made to produce such a device. After many experiments, both at Nahant and Schenectady, Dr. A. W. Hull and Mr. Chester Rice, of the Research Laboratory, developed a microphone support consisting of a rubber cup slipped over the end of a brass tube, the other end being inclosed by a suitable stuffing box. This arrangement, with a Submarine Signal Co. microphone or " button," gave an almost aperiodic receiver with complete binaural shift of the sound received, similar to the C tube and in its final form became the K tube unit or " rat " and was used in all of the later General Electric detection devices using microphones. A cross-sectional view is shown by photograph No. 74–271.

The K tube.—The K tube consists of three " rats," or K tube units, mounted upon a brass or galvanized steel triangle 4 feet apart, together with a metal float, lead weights, wooden floats, four-conductor cable, reel, deck cable, and compensator. It is shown on photograph No. 74–242, except for reel and compensator.

The OS tube.—The OS tube, produced in April, 1918, is a direction finder designed to tow from a ship, which will either listen while under way, if the sounds are satisfactorily loud, or, with power shut off, will listen while way is still on the ship. It was designed to improve the quality, range, and weight of the English listening device known as the " Nash fish."

With a chaser running at full speed readings are generally taken in from one to two minutes from the time that power is shut off. A submarine at 4 or 5 knots can be heard at distances from 1 to 5 miles, surface ships from 8 to 15 miles, and direction obtained on the average closer than 10°. The advantage of this device over " attached to the hull " devices is in the freedom from water noise, as it is usable under practically any conditions of the sea. It is materially lighter and has greater range and more discriminating power than the previously used English device. Approximately 210 complete OS tubes were built at the Lynn works.

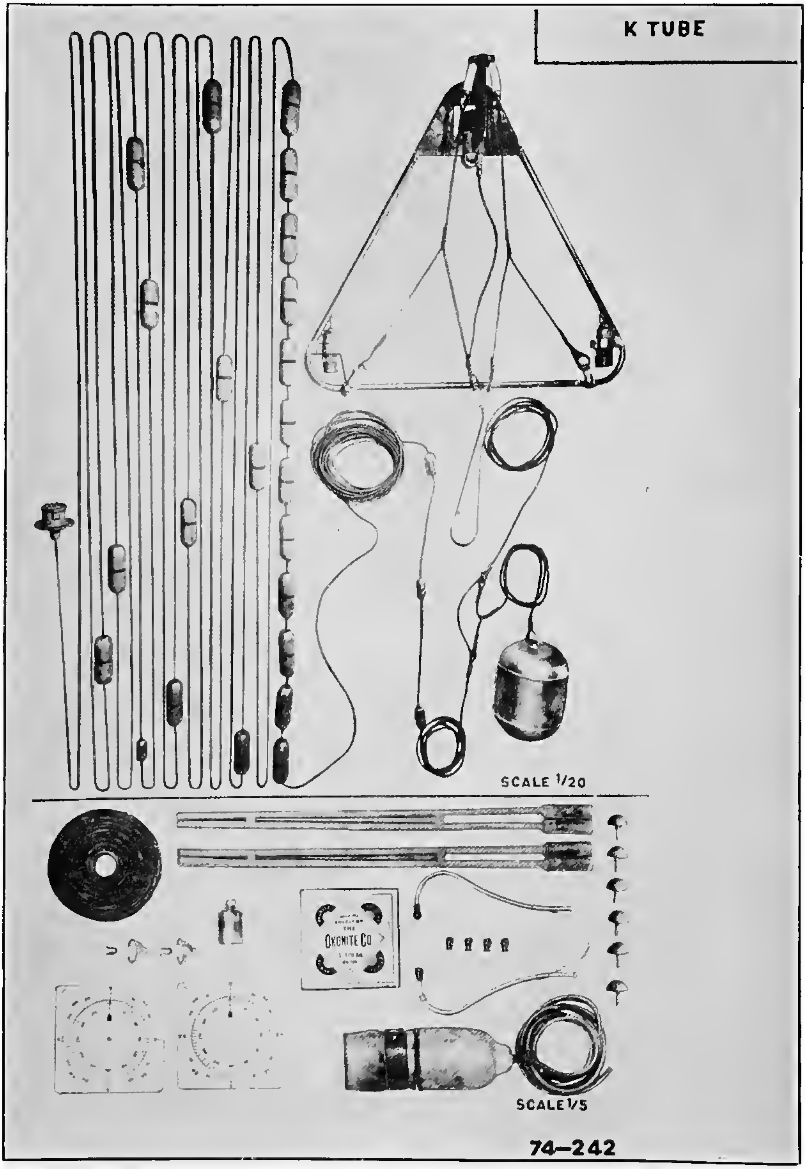
The complete OS tube consists of a steel stream-line spreader, three rubber fish, each containing a K unit or rat, which are towed from the spreader in the form of an equilateral triangle, 4 feet between the receivers, four-conductor towing cable, swivel reel, deck cable, and



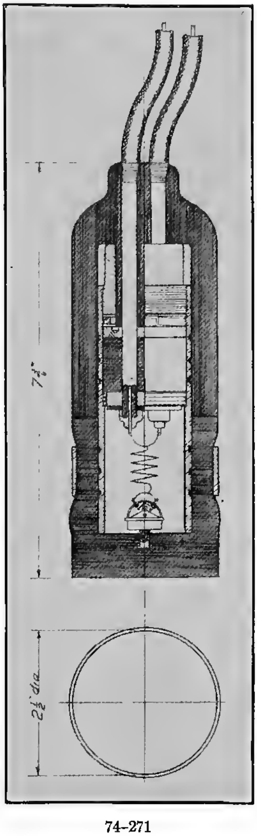
74–187

O. S. TUBE COMPLETE.

78–1



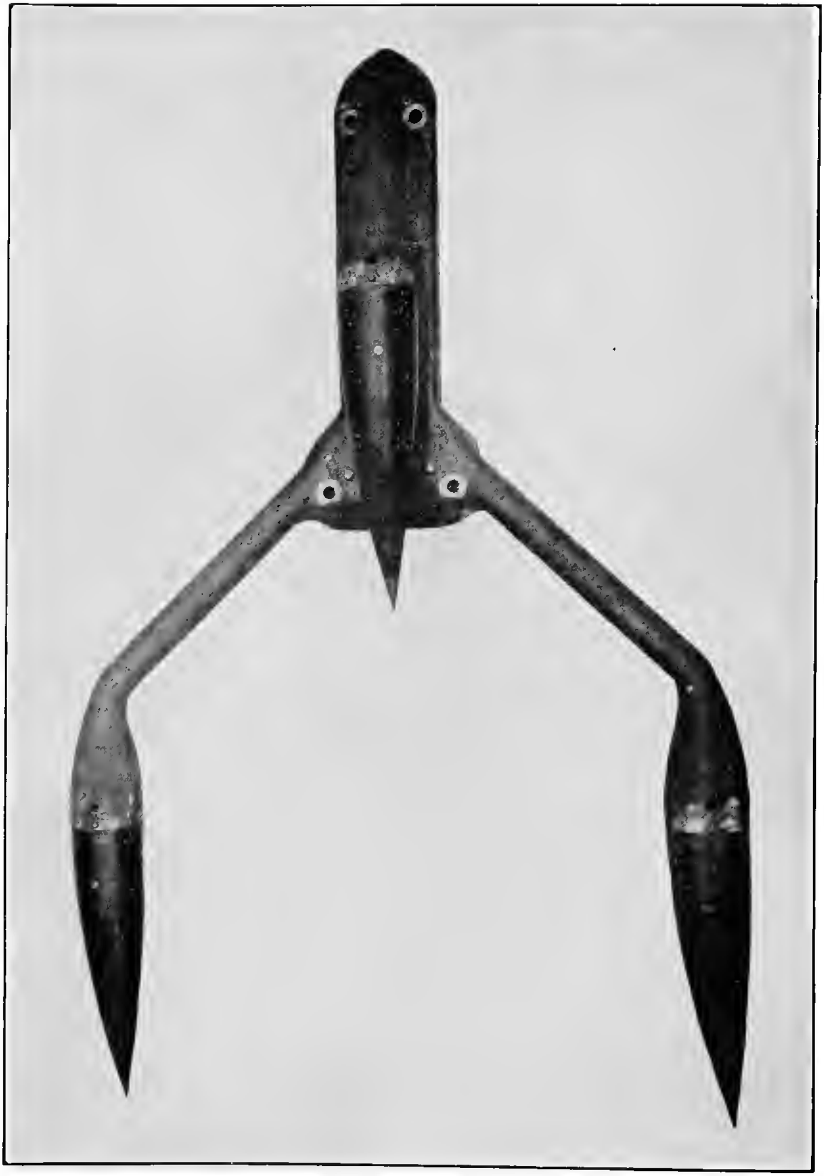
THE K TUBE.



74-271

THE K-TUBE UNIT.

78-3



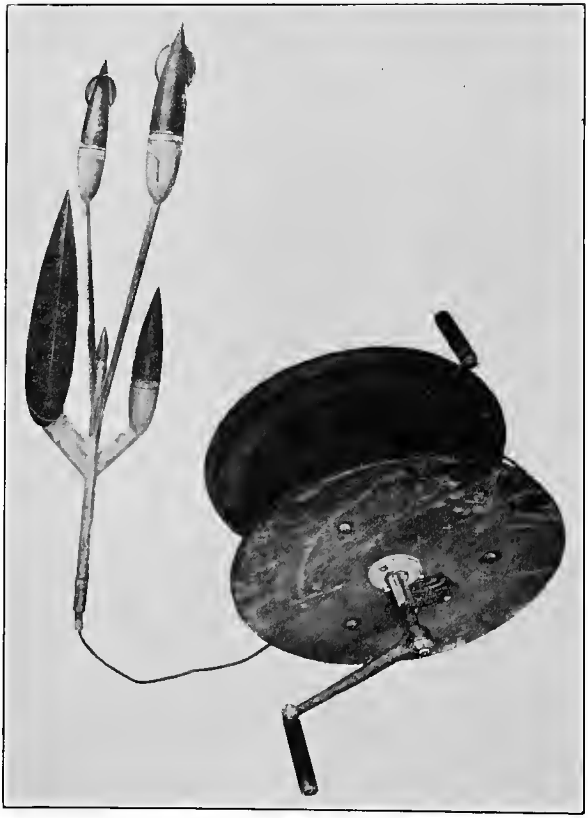
74–238

THE Y-5 TUBE.

79–1

74-237

THE Y-5 TUBE.



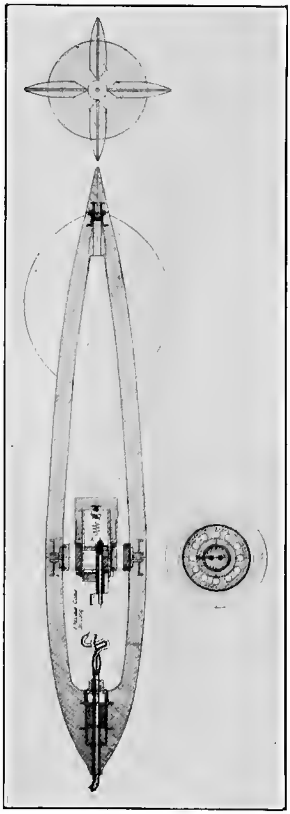
74-373

THE O. K. A TUBE WITH PROTECTORS.

79-3

74-374

THE O. K. TUBE.



74–225

THE O. S. UNIT.

compensator. The compensator is the same as the one used with the K tube. The OS tube complete is shown in photograph No. 74–187. A cross-sectional view is given by photograph No. 74–225. Before shipment every OS tube was given a sea test at Nahant by members of the Nahant group.

The OK tube.—After the development of the K tube and OS tube it was believed that a listening device combining the advantages of the towed and drifter type would prove very useful. Work was therefore started along these lines, and the OK tube was the result. The final form of the OK tube for surface-craft work is shown in photograph No. 74–374. This device consists of a metal stream-line spreader with metal float, which supports three K tube units inclosed in stream-line rubber protectors. It may be towed and used like an OS tube or used while drifting like a K tube.

A special light-weight OK tube for aircraft work was also designed and is shown with reel and cable in photograph No. 74–373. Its weight with protectors filled with water is approximately 30 pounds. With this device submarines were accurately followed while the airship was under way at something like 4 or 5 knots and the submarine submerged and distant 1,000 yards.

The Y tube.—On March 27 and 29, 1918, tests were made of a special K-tube outfit attached to the bow of the submarine *G–1.* This outfit consisted of a spar bolted to and overhanging the bow of the *G–1.* A head of a rubber fish was attached to the end of the spar and two other fish were held by iron arms bolted to the spar. The K-tube units in the three fish were spaced 4 feet apart. These tests proved so successful that they led to the development of the Y tube.

The Y tube, produced in April, 1918, is a listening device for use from a stationary or moving submarine. It consists of two sets, one for the deck and one for the keel, of three K-tube units inclosed in rubber stream line protectors and supported by a steel casting in the form of a triangle and operated with a compensator in the same manner as a K tube. The Y-tube casting with rubber protectors for K-tube units is shown in photographs Nos. 74–237 and 74–238. Four conductor cables run from the deck and keel installations to a junction box inside the submarine near the compensator. Here the compensator may be connected at will to either the deck or keel installation. The deck installation is used while the submarine is submerged, but the keel installation may be used while on the surface. Approximately 80 complete Y tubes each for deck and keel installation were built at the Lynn works. In addition 25 Y tubes for deck installation only were also built. The Y tube is now standard equipment for submarines.

The Delta tube.—The Delta tube devised in December, 1917, is a listening device designed for water or oil tank installations on destroyers. It consists of a steel spider supporting three K units spaced 4 feet apart and a compensator. It is operated in the same manner as a K tube or Y tube. Photograph No. 74–217 shows the Delta 5 or water-tank installation. Photograph 74–283 shows the Delta 6 or oil-tank installation. In this type the K units are inclosed in oil-tight metal containers, which are filled with water. A total of approximately 100 Delta tubes were built at the Lynn works.

Mr. B. G. Lamme became chairman of the Special Problems Committee, and as such took charge of the direction of experiments to find other methods besides those above described of detecting the submarine. Maj. (later Lieut. Col.) Ralph D. Mershon, United States Army, under the direct supervision of Mr. Lamme, conducted this work. Maj. Mershon devoted all of his time to it, and was attached to the Naval Consulting Board for this purpose. The great bulk of these experiments led to negative results. In work of this nature it was to be expected that by far the greater part of the schemes investigated would lead only to negative results. The object aimed at was to try out to a definite and final positive or negative conclusion those schemes for accomplishing a desirable end which were most promising, in view of existing knowledge, or in which lack of knowledge appeared to offer the possibility of a practical result.

The following is a summary of the results of this work:

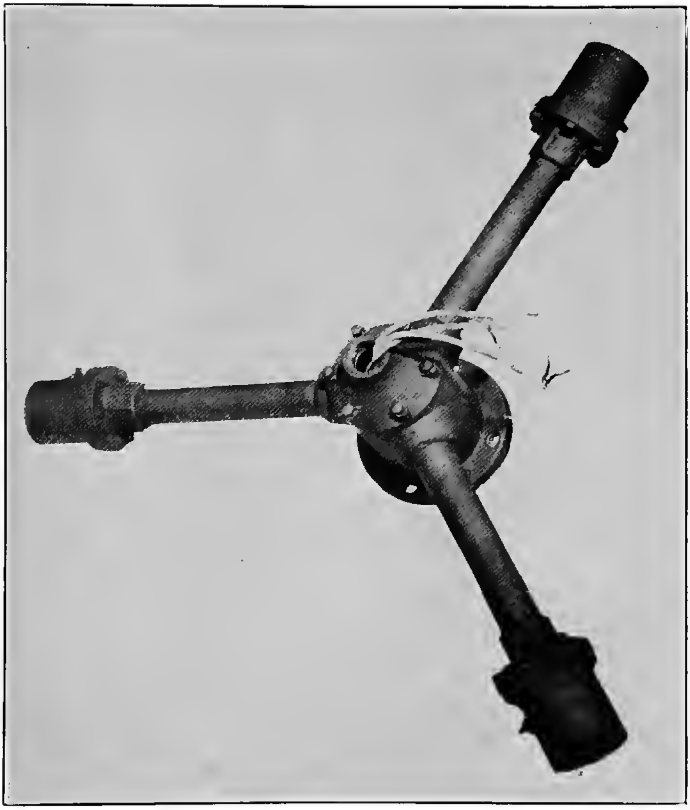
SUBMARINE DETECTION.

MAGNETIC NEEDLES.

(Under direction of Special Problems Committee.)

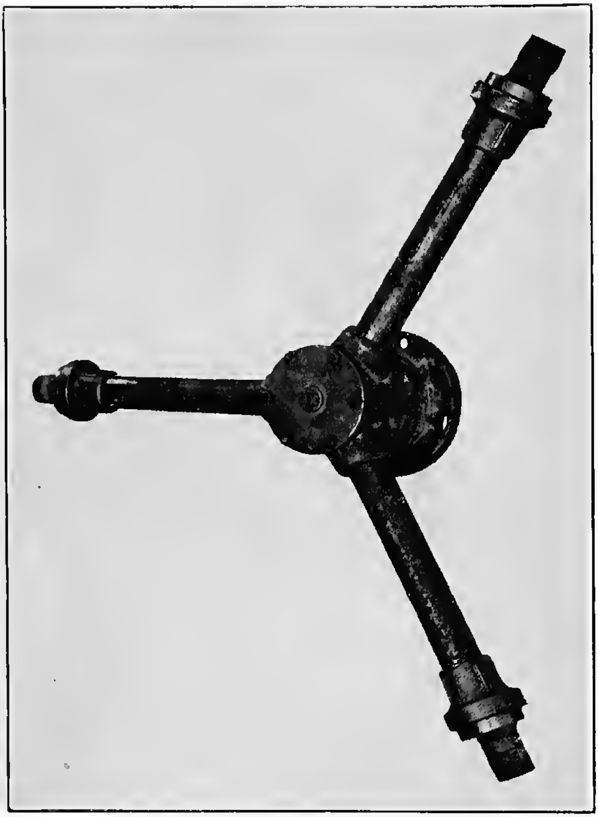
This work has to do with the detection of submarines by the deflection of some form of magnetic needle. It had its inception in the work done under the auspices of the Special Problems Committee, by Prof. C. F. Scott, of Yale University, and his assistants, in determining the magnetic field in and around a submarine. The problem of detection was then taken up by Profs. Nichols and Zeleny, of Yale University. These two men took up the work separately and worked along different lines. They both made use of magnetic needles, but they made use of them in distinctly different ways.

As the result of their preliminary work it became evident that in order to give this method of detection a thorough try out it would be necessary to have a stabilized and oriented platform or table,



74–283

THE DELTA-6 TUBE.



74–217

THE DELTA-5 TUBE.

on which to place the detecting instruments. Arrangements were therefore made by the board with the Sperry Gyroscope Co. to supply a gyroscopically stabilized platform. The tests were not completed.

HIGH FREQUENCY ALTERNATING MAGNETIC FIELD.

The method of detecting submarines by an alternating magnetic field involves the setting up of such a field by means of an alternating current magnet, and then detecting, through the change in the voltage generated in a coil, or coils, suitably disposed in the field, any modification of the field due to the presence of a submarine.

The use of an alternating magnetic field in the detection of a submarine was independently suggested by a number of people, including Maj. Mershon and Mr. Lamme. Experimental work was begun at 500 cycles. It was soon realized that the many apparent advantages of a frequency as high as this were accompanied by a number of very serious disadvantages. This made it appear desirable to experiment at much lower frequencies, as well as at 500 cycles.

At about this time it was ascertained that Prof. V. Bush, of Tufts College, had some time before begun experimenting along the same lines and at 500 cycles. Maj. Mershon visited him and found that he had the work so well in hand as to make it appear expedient for the Special Problems Committee to confine its activities to low frequency and assist Prof. Bush in every way possible in his high-frequency work. This policy was adopted, and every possible assistance that the board was able to give, except financial assistance, was extended to Prof. Bush. The expense of Prof. Bush's work was borne entirely by the American Radio & Research Corporation, at the instigation of its general manager, Mr. H. J. Power.

Although Prof. Bush has not realized as great a range of detection as was hoped for, he has achieved a range which will make his device of considerable value in the exact location of sleeping submarines, and in the accurate dropping of bombs upon them.

LOW FREQUENCY ALTERNATING MAGNETIC FIELD.

A series of experiments was conducted for the Special Problems Committee of the Naval Consulting Board by Mr. J. B. Whitehead and Mr. L. O. Grondahl.

The plan for the detection of submarines which was tested in these experiments was first suggested by Maj. Mershon. Briefly, it consists in locating a magnet excited by alternating current and two coils on the searching vessel. One of these coils is relatively large and at a distance from the magnet. The other coil is small and close to the magnet. The electromotive force in the smaller coil is adjusted so that it is exactly equal in magnitude and in phase to that in the larger, or detecting, coil. The two coils are connected in series with each other, the circuit including a delicate detecting instrument. If a submarine is in the neighborhood of a searching vessel it will upset the symmetry of the magnetic field, causing a difference in the electromotive forces in the two coils and a consequent indication on the detecting instrument.

Experiments exploring the possibilities of the method were carried on in three places: (1) In the Laboratory of Electrical Engineering, Johns Hopkins University; (2) at the Engineering Experiment Station, United States Naval Academy, Annapolis; (3) on submarine chaser *No. 326*.

The experiments at Johns Hopkins University consisted of tests of the physical laws underlying the method, the determination of unknown constants, and the devising and checking of a method for computing the size and performance of an enlarged equipment. The experiments were performed with a magnet 6 feet long and with submarine models 10 feet long.

The experiments at the Engineering Experiment Station were performed with a magnet 19 feet long and a detecting coil 7 feet in diameter, which were erected on the end of a pier extending into deep water. Detection tests were performed using the iron tug *Standish*, 180 feet long, and the converted yacht *Wasp*, 200 feet long. These vessels were detected at distances between 400 and 500 feet from the center of the magnet, and the results of a large number of tests were in conformity with predictions based on the Baltimore experiments.

NAVY DEPARTMENT,
Washington, June 23, 1917.

From: Secretary of the Navy.

To: Bureaus of Construction and Repair, Steam Engineering and Ordnance; Board on Devices and Plans connected with Submarine Warfare; Board to Consider and Experiment with Devices for the Detection of Submarines; Naval Consulting Board and National Research Council.

Subject: Detection and other Submarine Devices—Coordination and Organization of Efforts of various groups.

Inclosure: (*a*) Organization diagram.

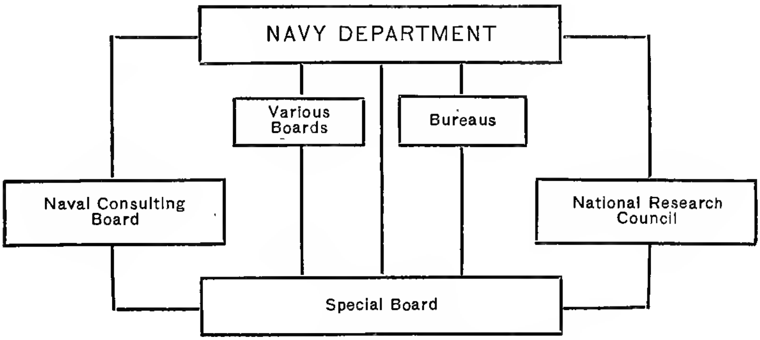
1. The department has approved the plan to coordinate and organize the efforts of various groups now considering submarine and antisubmarine devices and plans which is shown on the accompanying organization diagram. The cooperation of all concerned is urged in order that useful devices and plans may be put to actual use in the Navy at the earliest possible time.

2. It is the department's desire that the special board, of which Rear Admiral Grant, U. S. Navy, is senior member, shall have complete charge of the carrying out of experiments on submarine and antisubmarine devices, and that no device

of this nature is to be put in use in the service until it has been investigated and such installation recommended by this board.

3. It is desired that all devices and plans which are received by the department, the Naval Consulting Board, the National Research Council, the various bureaus, and other boards in Washington, be considered by them with such communications among themselves as necessary, and that these bodies act as filters to discard all manifestly impossible schemes and duplications of schemes already tried, these bodies to forward to the special board only such schemes as show promise and to give definite recommendations of what experiments they would consider desirable. If any of these organizations believe that any particular men are especially qualified to conduct certain experiments, they should make such recommendations to the special board.

JOSEPHUS DANIELS.



SUBMARINE-DEVICE ORGANIZATION.

This plan contemplates the closest possible cooperation between the Navy Department bureaus, Navy Department boards, Naval Consulting Board, and the National Research Council.

Approved:

JOSEPHUS DANIELS,
Secretary of the Navy.

CHAPTER V.

SHIP PROTECTION COMMITTEE.

As pointed out in the chapter on "Organization," the Naval Consulting Board was attached to the Navy Department, and its connection with this department was made through the Office of the Secretary of the Navy. Merchant-ship owners and captains of vessels were not entirely under the control of the Navy Department, and therefore the Naval Consulting Board, until the creation of the Ship Protection Committee, did not have any satisfactory method of introducing inventions to the merchant marine.

The campaign of the German submarines was directed against these merchant vessels, and the problem of conquering the submarine revolved about methods of protecting the ships and safely transporting their cargoes across the ocean. This great problem confronted all organizations that had anything to do with maritime or naval matters.

The Naval Consulting Board, after its creation, was given a great deal of publicity and the members of the board were widely known individually. It was therefore not surprising that the United States Shipping Board, hereinafter mentioned, and the Emergency Fleet Corporation, also mentioned hereafter, should take up with Mr. W. L. Saunders, chairman of the Naval Consulting Board, some method of organization by which inventions might be handled for merchant vessels. In order to understand the situation a short description is given of the organization of the United States Shipping Board and the Emergency Fleet Corporation and the development of the Ship Protection Committee through the cooperative effort of the Emergency Fleet Corporation and the Naval Consulting Board.

The United States Shipping Board was organized by act of Congress September 7, 1916 (see sec. 3 of the shipping act (30 Stat. L., 738, 729)). The act provides as follows:

That a board is hereby created, to be known as the United States Shipping Board, and hereinafter referred to as the board. The board shall be composed of five commissioners, to be appointed by the President, by and with the advice and consent of the Senate; said board shall annually elect one of its members as chairman and one as vice chairman.

The first commissioners appointed shall continue in office for terms of two, three, four, five, and six years, respectively, from the date of their appointment, the term of each to be designated by the President, but their successors shall be appointed for terms of six years, except that any person chosen to fill a vacancy shall be appointed only for the unexpired term of the commissioner whom he succeeds.

Under this act the Shipping Board became a part of the administrative machinery of the Government, designed in times of peace to promote the development of an American merchant marine and to regulate foreign and domestic shipping. It was given additional powers of an emergency character, intended to meet the shipping problems incident to consummation by the Government of its vast war purposes. The board, in the exercises of the powers conferred by later legislation, acted solely as the agent of the President of the United States.

The most important of the board's war powers were exerted by it through the instrumentality of the United States Shipping Board Emergency Fleet Corporation, the details of the organization and purposes of which were as follows:

The board was authorized by the shipping act to form, with a capital stock not exceeding $50,000,000, one or more corporations for the "purchase, construction, equipment, lease, charter, maintenance, and operation of merchant vessels in the commerce of the United States." The purpose of this authorization was to place vessels operated under Government appropriation on a competitive equality with private shipping, by exempting the latter on the one hand from governmental restrictions not adapted to commercial practice, and by withholding from them on the other such special immunity in domestic or international law as is customarily associated with governmental activity. The power under this act to operate ships is greatly restricted, but the power to build ships is limited only by the measure of the appropriations.

Acting under the authority of the shipping act, the board on April 16, 1917, organized under the laws of the District of Columbia, with a capital stock of $50,000,000, what is known as the United States Shipping Board Emergency Fleet Corporation, and delegated to that corporation the execution of its construction program.

The President, by Executive order, delegated to the corporation the comprehensive powers conferred upon him by the urgent deficiency appropriation act of June 15, 1917, in so far as they relate to the construction of vessels, and he made available to it the funds appropriated for this purpose.

The officers of the Emergency Fleet Corporation were president, vice president, second vice president, treasurer, and secretary. The trustees of the corporation, seven in number, were elected by and were under the control of the Shipping Board.

While in legal form a private corporation, the Emergency Fleet Corporation was in fact completely under governmental control. As a result the activities of the corporation and the board were closely interrelated.

Some time in May, 1917, Maj. Gen. George W. Goethals, at that time manager of the Emergency Fleet Corporation, requested Mr. William L. Saunders, chairman of the Naval Consulting Board, to have some member of the board visit him and discuss the question of handling the large amount of correspondence which he was receiving containing suggestions of ideas for protecting merchant ships from torpedo attack, and also in regard to various construction details which would render such vessels more immune to attack. At the request of Mr. Saunders, Mr. A. M. Hunt, a member of the Naval Consulting Board, went to Washington and had a conference with Gen. Goethals and also Mr. F. A. Eustis, who was at that time Gen. Goethals's assistant, and Mr. Theodore Brent, one of the commissioners of the United States Shipping Board.

Out of this conference there grew the idea that there should be a committee, limited in numbers, chairman of which should be an official of the Emergency Fleet Corporation in order to put behind the committee the authority and prestige of that body, and that one of the members should be a naval architect of experience, and the third member should be a man having experience with the operation of vessels; also that one of the members should be a member of the Naval Consulting Board. The above ideas were suggested by Mr. Hunt, and a few days after this an interview took place between Gen. Goethals, Mr. William L. Saunders, and Mr. Hunt, in which the general expressed his belief that the ideas suggested were proper, and he appointed the committee, naming Rear Admiral H. H. Rousseau as chairman of it and Mr. A. M. Hunt as a member. He selected W. T. Donnelly, a naval architect of New York City, as the third member. Rear Admiral A. R. Couden, United States Navy, was made a member of the committee late in the summer of 1917.

The committee was organized at once and proceeded to go through the large amount of correspondence which had accumulated prior to its appointment. Mr. J. G. De Remer was appointed as technical assistant to the committee and took charge of its office and routine work. After the formation of this committee and conference with the Navy Department it was arranged that all communications received by the Navy Department directly, or by the Naval Consulting Board, referring to ideas, suggestions, and inventions for the protection of merchant ships, should be turned over to the Ship Protection Committee of the Emergency Fleet Corporation for attention Thereafter the Navy Department and the Naval Consulting Board did turn over all devices of this character to that committee.

As pointed out heretofore, the Navy did not have control over merchant shipping, and the Naval Consulting Board, being attached to the Navy Department, also had no affiliation with merchant vessels, so that the formation of this Ship Protection Committee, in the manner above described, was an arrangement by which the United States Shipping Board and the Emergency Fleet Corporation would have the benefit of all ideas and suggestions for the protection of merchant ships that came to the Navy Department or the Naval Consulting Board.

During its early days the committee went forward with the above organization, but later in the summer of 1917 it was felt that the power of the committee might be somewhat increased if there were brought into connection with it other branches of the Government having to do with shipping, such as the Federal War Risk Bureau, the Export License Bureau, the Steamboat-Inspection Service, and the Navy Department. The committee was accordingly enlarged by the appointment of representatives of these Government bodies, and Mr. John A. Donald, one of the commissioners of the Shipping Board, became its chairman.

This committee was known as the Ship Protection Committee of the United States Shipping Board, and the original Ship Protection Committee above mentioned, started by Maj. Gen. Goethals, manager of Emergency Fleet Corporation, with the inclusion of Rear Admiral A. R. Couden, became the executive committee of the enlarged committee, and handled all the routine work. The larger committee was only called together at intervals when it was felt desirable to get the concurrence and cooperation of the departments of the Government represented.

The merchant vessels were under the control of individual owners and they were particularly interested in getting vessels loaded and back and forth across the ocean as quickly as possible. Freight rates were very high, and if a boat was sunk they felt that the insurance people made good their loss. The matter of the enforcement of ship-protection devices was therefore approached through insurance channels, as the only coercive instrument that could be used at that time on the shipowner. Subsequently, when the Shipping Board took over all ships, it had control of them.

The Ship Protection Committee was not an executive body and could only recommend to the Shipping Board the adoption of these various protecting devices. There should have been created a division of ship protection having coordinated authority and responsibility with other divisions of the Shipping Board to carry out the recommendations of the Ship Protection Committee. As a result, the committee had great difficulty in getting the adoption of its recommendations.

As the Ship Protection Committee had as one of its parents the Naval Consulting Board, and as the board was represented on its membership, the activities and conclusions of this committee were presented to the board for indorsement. The board had studied for months the subject of camouflage and smoke reduction in the danger zone. When the Ship Protection Committee made its report on this subject, signed by all the members of the committee and indorsed by Gen. Goethals, the board unanimously approved the recommendations and made an effort to have them put into effect. Much opposition was encountered because of the expense, most of the ships being operated by private owners. It was evident to the board that something should be done to distort the line of a vessel by camouflage and to reduce to a minimum the smoke discharged from the funnels of a ship when in the danger zone. Little or no progress was made either with the Government or with private individuals. There was no organized opposition, but nothing was done. The chairman, W. L. Saunders, laid the matter before President Wilson and suggested to him the advisability of having William G. McAdoo, Secretary of the Treasury, put his initiative and force into an effort to get the recommendations of the board put into effect. The chairman then took the matter up with Mr. McAdoo, who promptly and effectively caused a practical movement to be made through the Bureau of War Risk Insurance of the Treasury Department. A circular was issued by this bureau putting a penalty of about one-half of 1 per cent in insurance rates on all vessels clearing without a supply of anthracite coal for smoke reduction when passing through the danger zone and without proper camouflage and other safeguards, such as guns, etc., all of which were approved in the Ship Protection Committee report. These instructions placed the responsibility upon the chairman of the Naval Consulting Board to waive the penalty if conditions were found to warrant it. The result of this action was a gradual and general change of policy on the part of shippers, which led ultimately to the adoption of these protective measures.

Later all shipping was taken over by the United States Shipping Board, and the board began to carry its own insurance. It requisitioned these vessels on time charter, and they were operated at the risk of the United States Shipping Board as underwriters. They insured all vessels, and they therefore were in a position to make the vessel owners do as the board required. On October 15, 1917, the Shipping Board chartered every vessel of 26 tons carrying capacity or over to the United States Government through the Shipping Board, and they forced neutrals to come to the Shipping Board and take time charters from it by telling them that if they did not take the time charters from the Shipping Board on the same basis that the Shipping Board was paying its own people the Shipping Board would refuse them bunkers and stores. The effect of that was that the freight would be carried to the other side of the Atlantic on the same basis by neutrals as by American ships, the result being that both vessels flying the American flag and neutrals were under time charter to the United States Shipping Board and were therefore, to a certain extent, under its control in the way of insurance rates. The Government, to move ships before the war, had to provide insurance for them.

The committee in the meantime had secured a pamphlet of instructions issued by the British Board of Trade containing regulations to be observed by British vessels in the war zone and, using this pamphlet as a basis, prepared a similar one for adoption by the Shipping Board. This pamphlet of regulations was adopted by the board, and at the instance of the committee two inspectors were appointed, one with headquarters in New York City and the other at Norfolk, Va., to inspect all ships leaving this side of the Atlantic to see if the regulations had been complied with and were understood by the officers of the vessels.

The Navy Department did not allow vessels to sail unless they had guns placed on them in the manner which they directed, and with certain officers and men in the gun crew. The Shipping Board also arranged that all masters and other officers of merchant ships should cooperate heartily with the commander of the naval gun crew assigned to their vessels, and the following letter was addressed to masters and officers of merchant vessels, which was approved by William C. Redfield, Secretary of Commerce:

To licensed masters and officers of merchant vessels of the United States entering the war zone:

The department has had under serious consideration the very important proposition of the necessity of adopting and using every means and method to avoid so far as may be possible the attack of the submarine, and to this end it is suggested that when in the war zone or within dangerous areas during the night all lights that can possibly be dispensed with, including the signal lights, should be extinguished and such precautions adopted as will effectually blind every light on board to the observation of the enemy. There is offered for your serious consideration the suggestion also that regular or set courses should not be maintained, and that zigzag be adopted whenever the conditions of the weather and the position of the ship will justify such deviation from established practices of navigation.

Upon those ships which are armed, and the armament under the authority of an officer of the United States Navy, it is requested that serious consideration be given any suggestion from the naval officer on board respecting the navigation of the ship, and his suggestion adopted unless in the opinion and judgment of the master it can not be safely done.

Licensed masters and other officers are assured that the department will not attack their licenses for any collision or other accident that may result from the adoption of these suggestions respecting irregular navigation while in the war zone or within suspected dangerous areas, as the paramount desire is that every and all precautions be taken against submarine attack, and anything that may result from such precautions will be considered as the lesser of the two dangers.

GEO. UHLER,
Supervising Inspector General.

Approved May 25, 1917,
WILLIAM C. REDFIELD, *Secretary.*

The Shipping Board also directed that in the event of any differences arising with the commander of the armed guard the master of the ship should make an entry of such difference in the ship's log and forward copy of such entry to the nearest United States Shipping Board inspector, who in turn was directed to forward it immediately to the United States Shipping Board at Washington, D. C. The commander of the armed guard made full report to the Navy Department of any difference arising between the ship's officers and himself. It was then arranged that these two reports would be considered by joint conference between the Navy Department, the United States Shipping Board, and the Steamboat-Inspection Service, which conference was directed to recommend suitable action to the authorities concerned.

The regulations of the Shipping Board for the conduct of merchant ships were founded upon the report which the Ship Protection Committee made to Gen. Goethals some time in June, 1917. This report and correspondence in relation to it is as follows:

JUNE 9, 1917.

Mr. W. L. SAUNDERS,
President Naval Consulting Board, Washington, D. C.

DEAR SIR: I herewith hand you, in duplicate, preliminary report dated June 9, of the special committee which I appointed in consultation with you to study and report on the matter of protection of merchant vessels from attack by submarines.

The suggestions contained in this report are sensible, comparatively economical, and apparently will be effective. I approve of them and in order to get action on them would request that competent authority direct that they be given such trial and use as the urgency of the situation indicates is necessary.

Yours, very truly,

GEO. W. GOETHALS, *General Manager.*

JUNE 9, 1917.

Maj. Gen. GEO. W. GOETHALS, U. S. Army,
General Manager Emergency Fleet Corporation, Washington, D. C.

DEAR SIR: The special committee appointed by you to study and report on the matter of protection of merchant vessels from attacks by submarines submits the following preliminary report on certain specific suggestions with recommendations.

Item 1. Lower visibility of vessels by special schemes of painting.—Mr. William A. Mackey, of 345 East Thirty-third Street, New York City, has presented to us a system of painting vessels which in our opinion will lower their visibility. Fundamentally, it is based on mottling the surfaces with the three primary colors which at a distance blend to produce a gray having the quality of gray light. He also proposes to shade tints so as to lower high lights and raise low areas of illumination.

Through cooperation of Commander Fisher, United States Navy, Mr. Mackey is having some submarine chasers painted at the New York yard, which will be under observation next week. We believe that visibility can be reduced by proper methods of painting, and that the importance of so doing will justify the added expense.

Recommendation: If Mr. Mackey's system bears out its promises on test, we are prepared to recommend that the Federal War Risk Bureau and other underwriters be asked to require its adoption as a warranty clause in their contracts of insurance.

Item 2. Lower visibility by preventing smoke through the use of special fuel in daytime in danger zone.—Admiral De Chair, of the British Navy, in a conference with us stated that the suppression of smoke from the stacks of steamers would materially improve their chances of escaping the observation of submarines and consequent attack.

A number of elaborate and complicated schemes have been suggested to accomplish this result and have not seemed practicable to us.

One simple scheme capable of prompt application to all ships sailing from our eastern ports has been proposed. This consists in requiring all vessels that leave this side to carry sufficient smokeless solid fuel (i. e., anthracite) to take them through the daylight hours while they are in the submarine zone. Practically any vessel sailing between our coast and English or French ports can run the distance one way through the submarine zone and be exposed only during one daylight period, which as a maximum is 17 hours. The amount of anthracite coal that a steamer will burn in this time will be between 5 and 10 per cent of her total requirements, and it can be burned in the same furnaces and on the same grates as the ordinary fuel.

We have assurances from the chairman of the Coal Production Committee of the Council of National Defense that anthracite coal can be made available for this purpose at Atlantic ports.

Recommendation: We recommend that every steamer engaged in trans-Atlantic service be required to take sufficient approved smokeless fuel to supply her needs for two daylight periods, and be required to use same in accordance with prescribed regulations. This requirement can be promptly enforced by action of the underwriting agencies.

Item 3. Increasing offensive power by continuing to install naval guns aboard all merchant vessels that traverse the danger zone.—Information received by the committee is to the effect that submarines attacking merchant vessels armed or suspected to be armed generally feel obliged to use torpedoes and fire them at considerable range. They also do not like to come to the surface within gun range.

Recommendation: It would seem very necessary, therefore, as a means of increasing the defensive power by continuing to install naval guns aboard them as rapidly as possible. The committee assumes that this work would be, as heretofore, under the control of the Navy, and does not understand that any further action is necessary as regards this item.

Item 4. Increasing offensive power by installing at once on all merchant vessels that traverse the danger zones special howitzers, capable of throwing explosive bombs weighing from 100 to 200 pounds a distance of 2,000 yards and providing each merchant vessel with a large supply of bombs.—Submarines rarely come to the surface unless they are practically immune from damage by naval guns. Of equal or greater usefulness, therefore, would be the installation of a howitzer capable of covering the area within torpedo range and providing these howitzers with projectiles that by exploding at different depths, as determined desirable in advance, would practically search out submarines when submerged and would be able to destroy or damage them. This work is understood to have been thoroughly tried out abroad, with very successful results. It is understood that our Government has plans of different type howitzers and projectiles and has available data on all the experimental work and actual results. An ample supply of ammunition from 50 to 100 projectiles per merchant vessel is an essential element for success. Naval Constructor Stocker has suggested the furnishing of special projectiles charged with material that on exploding will form a smoke screen, which might be of value both in locating the place where the periscope or other object is seen as well as screening the vessel from the enemy. The committee believes that the suggestion should be adopted.

Recommendation: The committee strongly recommends that immediate steps should be taken to arm all merchant vessels with the greatest possible dispatch with weapons and ammunition of this general character. In addition to the explosive torpedoes it is recommended that special projectiles be also furnished that will on exploding make a smoke screen. This item, the same as the preceding one, would come under the Navy Department for execution, and it may be that steps have already been taken in that direction.

Item 5. Increased chances of escape by furnishing each merchant vessel with at least a dozen charges in wooden boxes which thrown overboard would ignite and form a smoke screen.—Recommendation: We recommend that all vessels operating through the submarine zone be required to carry on deck one dozen smoke bombs which will evolve smoke when thrown overboard. No detailed discussion of this is necessary.

Item 6. Increasing flotation of vessel after being struck with torpedo by the method proposed by Mr. Donnelly.—With reference to the possibility of so loading steel ships as to render them nonsinkable, discussed by the committee at the meeting on Saturday, June 2.

On Tuesday, June 5, Mr. W. T. Donnelly, of this committee and Mr. W. L. Saunders, chairman of the Naval Advisory Board, visited the following ships of the Atlantic Transport Line, *Manhattan*, *City of Cairo*, and *Cufic*, to observe the manner of loading and the interior structure affecting this problem.

The *Manhattan* was just commencing loading, the *City of Cairo* almost completely loaded, and the *Cufic* partly loaded, thus giving an opportunity for a general study of the problem.

It is to be understood that the fundamental principle under consideration is to so load a ship that there will not be sufficient space for water to enter in case of being torpedoed, it being understood and recognized that if it is possible to accomplish this, a ship and cargo can not be sunk by torpedo explosion.

The first observation made was to the effect that a very considerable space in steel ships, between the frames at the sides between the deck beams, and between stiffeners on bulkheads, is never used for cargo. This space is from 10 inches to 1 foot in dimension at right angles to the surface, and comprises the total surface area of the outer skin of the cargo holds, the total surface of all decks below the main deck, and the surface on each side of all bulkheads.

When it is understood that the flotation of the steel forming the hull of the ship, due to its specific gravity, requires a vacant space within the hull equal to seven times the volume of the steel, and when it is further understood that the thickness of the outer hull of an ordinary merchant vessel would be in the neighborhood of two-thirds of an inch, and that seven times this space will equal 4⅔ inches, it will be seen that the vacant space referred to will admit water of a weight greater than the structural weigh of the ship, hence the importance of eliminating this waste space.

The filling in of the waste space between the ribs and under the deck beams of a vessel, together with the space between the stiffeners on bulkheads, by small, water-tight structures of wood, would add a dependable buoyancy to a loaded vessel of 10,000 tons of 2,361 tons. Adding to this the buoyancy of the double bottom amounting to 1,851 tons would make the total dependable buoyancy to float the ship, independent of cargo, 4,212 tons. Against this we would have the submerged weight of the steel hull as 2,610 tons, and the machinery and stores 885 tons, or a total of 3,495 tons. In other words, it appears to be practical to support the total dead-weight structures of the hull by small water-tight structures placed in portions of the hull now used for cargo.

The further development of this plan of protection contemplates stowing the cargo to occupy closely all other space, either stowing portions of the cargo in water-tight containers or interspersing the light containers among the cargo, such as empty oil barrels in a cargo of heavy material.

It must be apparent to anyone that if the cargo itself occupies all the space and is of such a nature as not to absorb water, or if of a nature to absorb water it is so interspersed with other cargo or light containers, it will be entirely possible to have a ship which can be in a sense water-logged but can not be sunk.

The accompanying drawing No. 1 shows diagramatically the relative distribution of the steel-hull weight, the hull fittings, and machinery and stores; also the cargo-carrying capacity and the reserve flotation capacity due to freeboard.

I am also submitting herewith detail drawing showing the manner of constructing wooden fillers, and detailed estimate of their weight and displacement. It should be understood that it is not necessary to exclude all water from the hull by stowing of cargo. The margin of safety which is admissible is represented by the freeboard tonnage or the displacement between the full-load line and the main deck. Referring to the diagram, this displacement will be seen to amount to approximately one-third of the cargo displacement. In other words, a ship with this manner of stowing cargo would float with a small freeboard with 25 per cent of her cargo space full of water.

The foregoing is all on the supposition that all compartments have been broken and water enters freely over the entire ship. This, of course, is the most severe and, as a matter of fact, an unreasonable assumption. With one or more compartments intact, the safety of the ship would be entirely assured.

As an additional precaution, it is recommended that hatch openings be extended downward by an inverted combing of such a depth as to trap under the deck an amount of air which would represent in buoyancy the greatest load from below which the deck would sustain. By this method it would be possible to carry a very definite and considerable load by air under each deck, provided the deck was made water-tight otherwise than at the hatch openings.

To overcome the difficulty of making a deck absolutely tight, a reasonable amount of compressed air from a compressor located and operated from the upper deck would be an added safety.

Finally, it is believed that practical absolute safety of ships at sea with or without cargoes could be provided (1) by such water-tight bulkheads and double bottoms as at present exist; (2) supplemented by careful storage of emergency bouyancy in all waste space below the main deck; (3) by careful loading comprising the placing of light cargo in water-tight containers, and supplementing this by dispersing water-tight containers through bulky cargoes such as grain; (4) by adding reverse hatch combings to trap air beneath decks according to the strength of the deck; (5) by providing a source of compressed air upon upper deck to be used in pumping double bottom in case of the flooding of engine compartment.

Recommendation: We are prepared to recommend that the United States Shipping Board put the foregoing method of increasing buoyancy into effect at once on one or more of the vessels which it is operating at the present time, with the understanding that decision as to similar action being authorized on all of the vessels of the United States Shipping Board, both completed and under construction, await the result of this practical trial, and that simultaneously therewith the matter be taken up with the Federal and other underwriting agencies in an endeavor to secure their cooperation in putting the system generally into effect.

Respectfully submitted.

H. H. ROUSSEAU, *Chairman.*
WILLIAM T. DONNELLY, *Member.*
A. M. HUNT, *Member.*

The regulations issued by the Bureau of War Risk Insurance, and the form for collectors relating to the invisibility of vessels, are as follows:

With a view of minimizing the hazard to vessels trading to or from all ports to Europe and ports on the Mediterranean coast of Africa and vice versa, the following requirements will be insisted upon as to all vessels sailing to the above-named destinations on and after October 1:

1. *Arming.*—All vessels must be armed in accordance with the recommendation of the Navy Department, or in event of the Navy Department being unable to furnish such armament, the vessel owners must furnish to the Bureau of War Risk Insurance satisfactory evidence that such armament has been applied for and can not at the time be supplied.

The bureau will charge an additional rate of 1 per cent on each voyage on vessels failing to comply with this requirement.

2. *Regulations affecting visibility.*—(*a*) Each vessel shall be painted in accordance with one of the systems that are recommended by the chairman of the Naval Consulting Board and the Ship Protection Committee of the Emergency Fleet Corporation, as approved by the Bureau of War Risk Insurance. Information relative to these various methods of painting, and how the painting can be arranged for, will be furnished upon application by the Bureau of War Risk Insurance, Treasury Department, Washington, D. C.

It is to be understood that shipowners are free to select any one of the approved methods for their own use. Should a shipowner desire to follow his own method, it must first be submitted to and receive the approval of the chairman of the Naval Consulting Board, 11 Broadway, New York City.

Upon completion the shipowner must furnish the collector of customs at the loading port with a certificate from the party performing the work, certifying that the work has been performed and containing all necessary information.

(b) Coal: Each steamer at time of sailing from the United States must carry a sufficient supply of approved smokeless fuel to carry her for not less than two daylight periods, this coal to be used during the daylight runs while within the submarine zone.

Any steamer which is equipped with an approved system whereby the vessel may be operated without the emission of visible smoke from her stack shall be relieved from the above requirement.

(c) Smoke screen: All vessels operating through the submarine zone must carry on deck one dozen approved smoke boxes which will evolve smoke when thrown overboard.

Vessels must obtain from the collector of customs a certificate that all the requirements under the heading of No. 2 have been complied with.

In event of the failure to obtain such a certificate, the bureau will charge an additional premium of one-half per cent for each voyage.

The bureau reserves the right to decline to insure vessels whose owners have not in the opinion of the bureau made a satisfactory effort to comply with these requirements.

NOTE.—For forms of certificate for collectors of customs relating to invisibility of vessels, see Appendix, page 234.

In the early days of participation of the United States in the war the idea of camouflage had not been developed to the extent which later took place. The effort was first made to get reduced visibility, consideration being given to several systems, which included painting with various shades of gray, painting on the hull of the ships blotches of paint of the three primary colors which would at a distance blend to gray, and various other types which were intended to accomplish a similar purpose. As time went on the difficulties of reducing visibility by paint, owing to variable conditions of atmosphere and light, became more apparent. The Ship Protection Committee encouraged those who were engaged in the development of the art of camouflage, and valuable work in this connection was done by the Submarine Defense Association of New York, but the final development of the art of camouflage, which was known as the "Dazzle system," had its inception mainly with the British, although the idea may have occured and probably did occur to others on this side of the Atlantic.

The committee pushed the camouflage work and brought over English experts, who instructed American officers. The most practical method was found to be, as above mentioned, the English system of dazzle painting, which made it impossible through the periscope of a submarine to detect the course which the ship was steering. The Navy Department, which later took over the whole problem of camouflage, adopted this English method of dazzle painting in preference to making the ship invisible. Those on a submarine see a ship through a periscope; when the ship is camouflaged by the dazzle system and you look at it from the surface of the water you can not tell how fast it is going, or in what direction. If you are up at an elevation of 100 feet you could tell the direction, but from the surface of the water you can not. Camouflage was therefore successful for the protection against the periscopic view from a submarine.

Although, as above stated, the dazzle system, was the one in operation at the close of the war, there was a tendency to revert to some of the earlier work of American camoufleurs, as typified by the work of Mr. William A. Mackay, which was first called to the attention of the Naval Consulting Board in April, 1917, a few days after we entered the war. Mr. Mackay's scheme was based on the fact that daylight is made up of three colors—red, green, and violet; that we see them in the rainbow; that the distant horizon gray is also red, green, and violet. His designs incorporated the idea of painting the ship with broken patches of red, green, and violet in such a way as to make the ship melt away at a distance of 2 to 3 miles under most conditions of light. As stated above, the tendency was to come back to this scheme of invisibility from the dazzle system, for the reason that under the dazzle system, with the marking as large as it was, a technique had been developed on the part of the submarines which enabled them to judge the direction of the course that the vessel was taking.

The Naval Consulting Board, with its connection with the United States Shipping Board through the representation of Mr. A. M. Hunt on the Ship Protection Committee, and with the Navy Department, was in a position, after having brought about a meeting of the leading camoufleurs in America, to recommend to the Secretary of the Navy and to the Ship Protection Committee that the art of camouflage for use in eliminating ships, men, and other equipment outlined in time of war was founded on scientific truth and promised to be of great value.

The Naval Consulting Board, after this first meeting in April, 1917, continued to take an active interest in promoting the use of camouflage, and brought about having the vessels which had been painted in accordance with schemes of our outline observed by naval patrol boats and reports made thereon. As a result of this arrangement the men working on camouflage were able to develop their art based upon actual experience.

The Ship Protection Committee considered very carefully the proposal for reducing smoke issuing from the stacks of the vessels.

The use of pulverized coal was seriously considered for the following reasons:

1. Pulverized coal as a fuel is extensively employed in the arts for smelting, for burning Portland cement, and to a limited extent, for generating steam. It is estimated that 50,000,000 tons of coal have been pulverized and consumed within recent years in the United States. In stationary practice definite economies have been claimed

over the use of solid coal. From the above it appears that the art of pulverizing and burning coal as a powder has passed the experimental stage in certain arts.

2. Pulverized coal is a smokeless fuel, a fact of considerable military importance.

3. By a simple and immediate adjustment of the burners, powdered coal as a fuel may be made to emit dense clouds of smoke to serve as a screen, another fact of military importance.

4. In an emergency the ship's boilers may be rapidly forced, thereby increasing the steam supply and the speed of the vessel. This is a fact of military importance.

5. A great reduction in the fireroom force is effected, over using solid coal. This saving in man power has military value.

6. The supply of fuel oil in the United States, before discoveries in Texas of oil, was limited, and as a means of conserving fuel oil for naval vessels equipped to burn oil exclusively, the Consulting Board felt justified in encouraging the use of powdered coal as a fuel for merchant ships.

In the opinion of the Fuel and Fuel Handling Committee of the Naval Consulting Board it appeared feasible to equip merchantmen with requisite machinery for pulverizing and burning coal. The committee recommended that the Emergency Fleet Corporation authorize the preparation of the necessary plans and drawings for such an installation upon such ship, and that shore installation be made of such equipment to determine as well as may be the value of such an installation on board ship. Such shore installation could be set up and tested at the Annapolis Experiment Station, Annapolis, Md.

A ship equipped with pulverizing equipment should be expected to take on coal in any port of any kind available and by the ordinary methods. In Atlantic ports this will be run of mine bituminous of high volatile and of high grade, sometimes dry and dusty and at other times quite wet.

Such coal on board ship, following shore practice, would then pass through the following processes:

(*a*) Crushing in power rolls and delivering to a storage bin.

(*b*) Drying if found essential to remove the moisture prior to pulverizing, delivering to a second storage bin.

(*c*) Extraction of iron particles, this being advised to save damage to the pulverizing mill; a magnetic separator is commonly used for this purpose.

(*d*) Pulverizing, either in mills or their equipment, then storing in a third storage bin.

(*e*) Mixing with air, feeding to furnace, and burning.

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After delivery of the raw coal to crushers the fuel will be handled by conveyors or spouts. All storage bins, conveyors, and spouts must be constructed and maintained dust tight as a means to prevent explosions, and possibly such may have to be made of noncorrosive material.

Instead of the use of pulverized coal as a fuel in the vessels building and those already in operation, a definite recommendation was made that all vessels traversing the war zone should be required to carry a sufficient supply of anthracite coal to furnish fuel for two full daylight periods of steam, which would be sufficient to enable them to traverse the submarine zone as it existed at that time; and it was felt that this measure would be of material assistance in producing the desired result.

This suggestion met with great antagonism among the officers of the merchant marine, who made the claims that it would be very difficult to get this anthracite coal in the first place, and very difficult to keep it separate from the regular fuel in the second place, and that it would reduce the steaming capacity of the boilers and thereby slow the vessels down in the third place.

These claims had some merit, and as a result, at the direction of the President of the United States, Dr. Miller Reese Hutchison, of the Naval Consulting Board, conducted certain steam tests with anthracite coal on one of the Clyde Line steamers. Reports of this test indicate that with proper handling of anthracite coal there was no difficulty in keeping up steam, and the combustion was practically smokeless. Certain special methods of stoking the furnaces had to be adopted, however, to overcome the difficulties in burning anthracite coal under these conditions.

The Committee on Ship Protection also made tests at the United States Naval Engineering Experimental Station, at Annapolis, Md., in burning various mixtures of anthracite and bituminous coal under the test boiler at that station. It was found that fairly satisfactory mixtures of anthracite and bituminous coal could be used with very light production of smoke and still maintain boiler capacity approximately normal.

Mr. Hunt became interested in the possibility of firing boiler furnaces with what might best be termed granulated coal, or bituminous coal that have been put through a crusher so that there were no particles larger than about one-fourth inch cube. In developing this idea it was finally decided that if this granulated coal could be fed into a stream of air carried in a pipe with continuous discharge on the fire bed, that good results would be obtained. In cooperation with the Bureau of Mines, in determining the relation between the quantity of air and the quantity of coal which could be handled in this way, following the experiments an installation was made at Annapolis, Md., under one of the boilers at the experimental station, and was operated at intervals of several months. The results were quite favorable. An installation of this system of firing a steamer was made on one of the boats of the Central Vermont Transportation Co., operating between New London and New York. It was found that there was a marked difference in the results obtained at Annapolis and on the steamer, due to different methods followed; and while the experiments were not carried to a full conclusion, the results were of such a character as to indicate a rather important development, and seemed to indicate that valuable results would accrue if followed out to a conclusion.

Consideration was given to the possibility of electrical precipitation of smoke from the stack, and after some preliminary work had been done by the Research Corporation of New York in this direction, it was decided not to prosecute the matter further, as it was felt that other methods were simpler, and the difficulties attending such installations for marine work and the requirement for intelligent and skilled supervision might possibly render such a device inoperative when most needed.

Consideration was also given to several suggestions which had been proposed whereby smoke could be discharged through horizontal lateral flues, within which the gases of combustion would be scrubbed by showers of water which would tend to eliminate the carbon particles and also to cool the gases so that they would not rise in the air but lie as a blanket on the surface of the water.

This idea was afterwards brought out in England by Sir Alfred Yarrow, and one or more vessels were so fitted by the authorities on the other side.

The committee also made a definite recommendation that tests and experiments should be carried out by the Shipping Board in the adoption of a system of cellular buoyancy in vessels traversing the submarine zone, on a system devised by Mr. Donnelly, who was a member of the committee. Ultimately authority was given to equip one ship in this way, which was finally done after considerable delay due to difficulties in carrying out any new idea of this kind.

At a meeting of the Naval Consulting Board on February 16, 1918, the following resolution was passed in regard to the *Lucia:*

Whereas the Naval Consulting Board has had presented to it this date a copy of a resolution passed by the Ship Protection Committee of the United States Shipping Board bearing date of February 11, 1918, and copies of which were transmitted by Mr. Hurley, chairman of the Shipping Board, to the Secretary of War and the Secretary of the Navy: Be it

Resolved, That the Naval Consulting Board commends to the War and Navy Departments or to such department as has responsibility for the transportation of troops the serious consideration of the system installed upon the steamship

Lucia, or an equivalent system of reserve buoyancy, for application to troop transports, in order to increase the safety of transportation of our troops to Europe.

The Lucia was equipped and later torpedoed, and the following is a report on the sinking of the vessel:

NEW YORK, *January 4, 1919.*

CONDITION AT TIME OF TORPEDO ATTACK AND SINKING AS DEDUCED FROM EVIDENCE GIVEN BY OFFICERS OF THE "LUCIA" AND CONCLUSIONS THEREFROM.

[See Report of Ship Protection Committee under date of "Washington, D. C., Nov. 8, 1918."]

The steamship *Lucia* was torpedoed about 5 p. m. on October 17, 1918, approximately 1,250 miles off the Atlantic coast, on her way to the Mediterranean.

At the time of the attack the *Lucia* was in company with four or five other vessels, but the fleet was not convoyed.

According to the evidence of the captain and other officers, the ship was struck in the engine-room compartment just forward of the after engine-room bulkhead on the port side, so low down that the double bottom was damaged as well as the pump connections for the double bottom and other water-tight compartments aft.

The explosion was so low that no damage appeared on the outside of the hull, even when the ship rolled.

At the time of the attack the *Lucia* was drawing 27 feet 6 inches forward and 28 feet 6 inches aft.

The engine and boiler room were one compartment, and hold No. 4, next aft, flooded immediately. Hold No. 5 subsequently flooded over partial bulkhead between 4 and 5, which only extended to upper between decks. Subsequent soundings showed water entered hold No. 6 from below, evidently coming through broken connections from drainage system.

From statement of Capt. Leary (see p. 9 of testimony) before committee, one-half hour after torpedoing the *Lucia* floated with about 4 feet freeboard.

The *Lucia* floated through the night, gradually settling aft with about 2 feet freeboard on the morning of the second day. (See p. 11 of Capt. Leary's testimony.)

At the bottom of page 23 and top of page 24 will be found the statement of Capt. Leary, in response to a question by Capt. McAllister, that the *Lucia* was flooded when she sank from No. 2 hold right aft, and that Capt. Leary heard a noise and shock, which he believed to be forward bulkhead of engine room connecting to No. 2 hold let go, sometime the following morning. It is further brought out on page 24 that the ship was capable of defense by both guns until about noon the next day and with the forward gun until a few minutes before leaving the ship.

At the bottom of page 11 is a statement made in reply to the question if it was the heavy weather that caused the final sinking, Capt. Leary replied it had a little to do with it. She would have floated if it had not been for the trucks smashing in the aft hatch; when she broke in the hatch it filled from the top; the statement being further amplified that it was the thrashing about of the deck load of trucks which smashed the aft hatch.

It is noted on page 12 of the testimony of Capt. Leary that the *Lucia* floated the next day with a list of about 3° to port. On page 12 will be found the statement of Capt. Leary that the *Lucia* sunk at 3.20 in the afternoon of October 18, slightly more than 22 hours after the torpedoing.

It is noted on page 12 that in finally sinking the *Lucia* settled aft until she stood vertical, with about 175 feet of her length in the air.

General conclusions deduced from information submitted herewith:

By referring to tabulated information, sheet No. 1, showing a comparison of weights and displacement of ship and cargo, it will be noted that the total weight to be supported was 12,991 tons and that the total displacement of this cargo, considering displacement of buoyancy boxes, and also that all compartments and double bottom are flooded, was 11,585 tons. This would make the excess of weights 1,406 long tons more than the displacement.

By reference to report giving information relative to the equipment of the *Lucia*, it will be noted that the double bottom, which was depended upon for buoyancy, had a displacement of 1,600 tons. From this it will be seen that had the double bottom remained intact, or any one of the other water-tight compartments aft, the *Lucia* would have remained afloat indefinitely.

That the *Lucia* had a freeboard of 4 feet one-half hour after she was struck and a freeboard of approximately 2 feet the next morning, or some 14 hours after being torpedoed, shows that the displacement of the buoyancy boxes, in so far as they provide buoyancy, sustained the vessel in a very remarkable manner.

Particnlar attention is called to the fact that the *Lucia* floated a considerable time after every compartment except No. 1 hold forward had been open to the sea, and that, according to the report of her captain, the final sinking was brought about by the destruction of the aft hatch of hold No. 5 and the complete flooding of this hold from the deck.

Referring to tabulated information, sheets Nos. 2 and 3, which deal with the specific items of cargo and their weight and measurement, it was found upon carefully reviewing these in connection with stowage plan (see accompanying sheets prepared by Ship Control Committee, also sheet No. 8 and diagram drawing No. 1) that in hold No. 1 there was vacant space of 10,700 cubic feet; in hold No. 2 vacant space 29,928 cubic feet, aft holds being practically full. This makes an aggregate of space not used of approximately 40,000 cubic feet.

By reference to copy of letter under date of September 25, giving loading agreed upon, and attached copy of comparative figures giving actual loading, if will be noticed that instead of 700 tons of shrapnel 1,214 tons were actually carried. If this amount of excess shrapnel had been replaced by 500 tons of hay, there would have been left only approximately 7,000 cubic feet of empty space, and the excess of weight over displacement would have been only 550 long tons.

This comparison is made to show the importance of loading in connection with interior buoyancy.

Had the *Lucia* been loaded with 8,800 tons of coal, as originally provided for, the ship and cargo when completely water-logged, other than double bottom and shaft tunnel, would have had a weight of 13,040 tons, with a displacement of 14,180 tons, or a recerve buoyancy of 1,140 tons, it being understood that these figures are made considering the double bottom and shaft tunnel as intact.

Respectfully submitted.

WILLIAM T. DONNELLY.

The committee also recommended that vessels traversing the war zone should be equipped with howitzers of limited range which would be capable of throwing the equivalent of a moderate size depth charge for defense against the submarine when it was submerged.

The Navy Department, which had charge of the arming of merchant vessels, had some of these howitzers in course of construction, which were to have been ultimately tried out. During the later days of the war reports came to the committee that weapons of this type had been fitted to one or more British merchantmen.

The theory of the use of this weapon was that a submarine submerged after attack by the regular naval guns mounted on the merchant vessel, and if the bomb thrower had been available, it would at least have had a long chance of crippling the submarine or at least demoralizing it and prevent the torpedo attacks which followed. One objection against the use of this type of gun was the fact that the decks of a merchantman would have to be reinforced to take the downward thrust of high-angle fire. To meet this objection it was suggested that a cluster of bomb throwers of small size, of a type of the old pepper-box pistol, consisting of 36 steel pipes, 6 inches in diameter and in length from 6 to 8 feet, so mounted that there would be a dispersion of projectiles leaving them, so that the area within which the submarine might be would be peppered by small depth bombs, and there would be a strong probability of a direct hit by one of the bombs on any submarine within that area. It was planned that these 36 bomb throwers would be fired in succession by timing intervals, the time interval between successive discharges being that necessary for the projectile to travel the length of the bore. This would reduce the downward thrust materially.

Early in the summer of 1917 an idea occurred to Mr. A. M. Hunt, the Naval Consulting Board member of the Ship Protection Committee, that a mine might be constructed containing a magnetic device which would be operated by a sufficiently large mass of iron being brought into its field and thereby fired. He made certain preliminary tests by placing suspended magnets in proximity to a railroad track and running a locomotive back and fourth past the instrument placed at varying distances. The effect noted was sufficient to make the idea seem possible to realization, and an appropriation was made by the Naval Consulting Board to have additional work done under its Special Problems Committee.

The matter was placed in the hands of Lieut. Col. R. D. Mershon, of the Army, who was detailed for duty with the Naval Consulting Board, and after consultation with Mr. Hunt, the actual work was undertaken by Prof. Nicholls, of Yale University. After some months' work he had developed a device that was of such a character that it was deemed advisable to bring it to the attention of the Bureau of Ordnance of the Navy Department. Prof. S. J. Brown, United States Navy, was detailed to visit Yale University and look it over. After his inspection, which was some time in December, 1917, he stated that the department was already working on a device along somewhat similar lines and suggested that the whole matter, in its then form, be turned over to the Bureau of Ordnance. Thereafter this matter was followed up by the Bureau of Ordnance, and the work contributed by Prof. Nicholls was of value as a contribution to the ultimate result obtained.

Mr. Hunt also carried out work in connection with the protection of smoke screens for concealment of a vessel in case of attack by submarines. One series of experiments was carried out by the Standard Oil Co. of New York and the Barrett Co. working jointly. The primary idea was that of endeavoring to float a film of oil on the surface of the water and ignite it, the incomplete combustion producing a heavy smoke. The Standard Oil Co. furnished a boat and several tests were made in the lower New York Bay. It was found difficult to get a film of oil to burn on the surface of the water. Fair results were obtained by a crude raft which could be floated astern and on which were placed a mass of oakum and other fibrous materials saturated with the oils. An amount of solid bituminous material was also used by throwing a shovelful in on the fires, so as to quickly and promptly create a dense smoke; this was found to be quite effective. The smoke protection in general use was the so-called phosphorus type, and as there were numerous reports of accidental fires on board ships carrying this type of smoke box, zinc dust was tried and burned in a torch in order to produce a heavy cloud of white smoke. The results were quite successful. But about this time a more desirable form of smoke protection was devised, and the matter was dropped.

The committee tried out a scheme for the concealment of vessels by means of a screen consisting of a water spray. The test was made in New York Harbor after certain preliminary tests had been made on the shore. The general results were not satisfactory, although it would probably have been desirable to carry the tests to greater extent than was done.

The Ship Protection Committee and the Naval Consulting Board received thousands of suggestions for all forms of towing shields or nets for the protection of vessels against torpedoes, none of which were practicable or possible of adoption. Reduction of speed by any net or shield that is of a form to offer direct opposition to the passage of a torpedo is so great as to make such a device impracticable.

Even a mesh approximately 3 feet on a side and made of five-sixteenths wire strands imposes sufficient resistance to the motion of a vessel to be a very material factor. The function of this type of net was to entangle and divert and possibly cause the explosion of a torpedo at a sufficient distance from the ship so that the damage would be limited or negligible, and not to stop it by direct opposition.

Reports having come to the committee that this type of net had actually stopped a torpedo on several tests on the other side of the ocean by entangling the blades of a propeller on a torpedo in the meshes of a net, active work was taken up on this type of net and an appropriation was made by the Shipping Board to carry it forward. It was placed under the direction of Mr. Hunt, who proceeded to New London, Conn., and made arrangements for carrying out these tests. They were not completed, however, at the time the armistice was signed.

The work which was done there was directed to the development of a system in which the towing would be done from whisker booms stepped on the side of the ship well forward and extending out at an angle of about 45° with the axis of the vessel. The towing line would in this case lead at a right angle to the axis of the vessel from the stem around the end of the boom down to the forward edge of the net.

In nets which were used abroad and in experimental work in this country it was found necessary to use what is termed "water kites" to hold the lower edge of the net down, and in some instances to keep it breasted out from the side of the vessel. These kites were quite erratic in action. A type, however, was developed that was very effective in this connection.

The decrease in maneuvering ability and speed of a ship depends on the type of net and its resistance to towing. Resistance to any body moving through the water increases very rapidly. The power required increases as the cube of the speed or higher function. These facts taken into consideration, also the fact that the head of a torpedo is provided with net cutters has caused practically the discard of the use of a net. It is probable that the Germans did not use these devices, as there was no call for them. But had nets been adopted, it would have been the answer to them. As stated above, therefore, the development work at New London was to entangle and not to stop a torpedo.

It is essential that a net or other protective device of that character should be such as to permit a prompt lowering of lifeboats. To be successful in preventing serious injury to the vessel, the net should be carried not less than 35 feet from the side of the vessel and preferably more. This involves carrying them either at the end of long booms attached to the side of the vessel or carrying their weight by means of floats. In the latter case it would, of course, be necessary to provide some device that would maintain the net at its proper distance from the ship's side. As a towing line of a net could not be fastened to any point farther forward than the stem of the vessel itself, it is of course evident that it would be very difficult to so fasten a net that it could cover the entire broadside.

Another matter was given a great deal of thought and study, even to the point of developing designs, and that was the protection of vessels by means of blisters; and various forms of blisters were tried in cases abroad, but they were not deemed practicable for general use.

A great number of minor matters were acted on and suggestions made by the committee. For instance, many reports were received that the lights at night were being burned in such a way as to betray presence of a vessel. Doors of outside staterooms would be left open with lighted lamps inside. Recommendations were made to the Division of Operations that all ship wiring should be so fitted that staterooms would have a switch in the door casing, so that when the door was opened the light would be extinguished. It was recommended that all deck lights which were necessary to use should be covered by blue shields so that the light would be invisible beyond a few hundred yards.

The following story is told of the fearlessness of the officers of merchant vessels to submarine attack: A chief engineer of a ship sat in his cabin smoking, with the ports open and his lights on. He would not turn them off, and the officer in charge of the guard was obliged to take a revolver and blow his lights out so that he could not use them.

This is an exceptional case, and as a rule merchant captains and the crews tried to do everything possible to prevent submarine attack. Among certain of them, however, there seemed to be a feeling that it was unsportsmanlike to be overcautious.

A large number of forms which might be called a breech mat rigged in ways which would enable it to be brought in place before the hull would fill with water were considered. The possibility of the use of such a device would depend very largely on the extent of the injury caused, and in the majority of cases the injury was of such a character that no mat of such a size that could be carried or operated would serve.

At the time of the signing of the armistice a form of mat had been built and was ready for testing. It was thought that this mat had greater possibilities than any of the others that had been seen.

In the summer of 1918 steel and wooden bulkheads were placed in the holds of ships to subdivide them. A test was made on the S. S. *West Eagle*, which was laid up for a month for this purpose. After the bulkheads had been placed in her, her three holds were filled right up to the top deck with water, and it was demonstrated to a large group of scientists and others that the ship could remain afloat with three compartments full, and this method of ship protection seemed very good. Calculations made by an eminent naval architect as to the effect and the draft of water that a vessel with a cargo of coal and iron ore which filled one, two, or three compartments showed that a vessel would float all right with these compartments full, depending on the cargo and the density. In general, the cargoes which were being carried across the ocean were more favorable to a ship than iron ore. These bulkheads could be put in after the cargo was in place, and taken out before the cargo was discharged.

However, those who were responsible for getting the cargoes, munitions, and troops to France said it would interfere with the stowage of the ship to have so many bulkheads, and there would be loss of time both in the loading and discharging of cargo. As a result, but one ship was fitted with this system of protection.

The question of operating by means of the convoy system was given consideration by the committee. Convoy operation, of necessity, reduces speed and time of passage, as the convoy is limited to the speed of its slowest unit. It is possible that this defect in the convoy system might, to a certain extent, be eliminated if the use of granulated coal could be brought to such a point as to increase the speed of the slowest vessels sailing under convoy, and thereby increaese the average speed of movement of the entire convoy of the increase the average speed of movement of the entire convoy of the pointed out above, could have increased their speed, and the convoys could have been made up so that the individual elements of the convoy would have had closer uniformity, and especially if there had been an opportunity to train officers to operate closely in convoy, the convoy system would have been greatly increased in efficiency.

There is, however, probably no question that the most effective thing developed during the war for protecting vessels was the convoy system. After it was adopted, any system of reducing visibility of ships either by suppressing smoke or camouflage became more or less futile, as it is impossible to keep all vessels of a convoy smokeless all the time. It may be said that one of the convoy would be making smoke all the time, so that with a fleet of vessels steaming in close formation, very little could be done to prevent it from being seen. The safeguarding of the vessels by torpedo-boat destroyers and armed vessels was very effective, and with a sufficient number of destroyers practically complete immunity from submarine attack might be had.

At the outset of the introduction of the convoy system practically all the merchant skippers detested it, and there were many instances where the captain of a vessel would take advantage of darkness or fog, or confusion in convoy, to strike out "on his own hook," because in all cases, except that of the slowest vessels, the captain felt that his speed was being cut down, and his speed was a very important factor in shortening his time in the waters infested by submarines, and a quick-moving vessel is better able to a void an attack. In other words, he would rather rely on his speed than on the destroyers.

The convoy system was adopted in the summer of 1917, and the intensified moving of American troops to France was greatly facilitated by it. The German submarines did not torpedo one eastbound troopship, except a ship which was sunk around Ireland.

The Germans did not like to attack numbers of ships when they were together. The submarines liked to single a ship off, because she is defenseless. Where a submarine comes near a group, there are several defenses, and the naval vessels accompanying the convoy made it very dangerous for any submarine to attack a convoy.

It is probably safe to say that the submarine was conquered by tactics rather than devices. However, this is to be noted, that the submarine warfare was not a fixed thing; it varied from time to time. There were times when the operation of the submarines was close inshore and near the entrance to harbors; but when the listening devices and patrol work became active, the submarine found an unsafe game inshore and began to work farther and farther out to set. This was brought about by the large increase in the number of vessels available for patrol work and by the increase in efficiency in detection devices, for even in the earlier and crude forms listening devices played a part. As our listening devices increased in accuracy and sensitiveness, the Germans did everything possible to quiet and reduce all noises that a submarine might give out. It was understood that the Germans tested each submarine at various speeds, in order to determine at what speed the least vibration and noises occurred. This having been determined, the vessel navigated at that speed when it suspected the presence of vessels with listening devices aboard.

The Shipping Board was overloaded with work and was being pressed at all times to provide ships for the movement of freight, and it was not thinkable that they could divert themselves for one moment from this end and purpose. To a degree, at least, it was the immediate momentary urgency upon them which controlled and governed their actions.

It was realized that the whole problem resolved itself into a matter of tonnage movement, and that any protective device or system of operation which reduced materially the amount of tonnage which could be handled across the ocean could not be adopted.

There were sent to the Ship Protection Committee an immense number of suggestions for the protection of merchant vessels that were impracticable. The volume of these suggestions can hardly be imagined by those who are not familiar with it. The committee was always careful to give full consideration to everything that it received, even though the ideas were crude, and endeavored to find in them some germ of merit that might be of service. There were, however, very few that were of any value.

In conclusion, it might be said that the object of a ship is to carry material across the ocean. If you reduce the carrying capacity you have lost your purpose, and it is better to lose a few ships, from a naval point of view, and get the cargoes across, so that many of the protective devices which theoretically would have preserved a ship from being sunk by a submarine, in the light of the above objective, could not be used.

On or about June 27, 1917, the Submarine Defense Association was formed to cooperate with the United States Government in seeking devices for the protection of merchant ships against attack by submarines. It sought to accomplish this result by bringing devices to the attention of shipowners and underwriters. The members of this association were the large insurance and steamship companies and corporations engaged in foreign trade, to whom the question of submarine detection was one of vital business interest. Experts were employed by the committee, who made exhaustive studies of the whole submarine question, particularly camouflage, the maneuvering of vessels as a defense against attack by submarines, including the different zigzag courses to be taken by ships, and the escort and convoy system.

CHAPTER VI.

LABORATORY.

At the time of the organization meeting of the Naval Consulting Board, October 7, 1915, the members realized the necessity for the construction of a naval laboratory in order to get the best results from the work which they proposed to do along scientific and inventive lines. It was realized that the navy yards and their facilities were fully occupied with the active work of construction and with the maintenance of the fleet as their primary function, and that anything in the nature of experimental work had to be inevitably subordinated to the exigencies of this primary function, and that it suffered accordingly. It was therefore felt that facilities primarily intended for investigation and experiment should be provided; for instance, if in a new battleship new elements and devices were to be incorporated, orders could be given immediately for getting out and testing at the laboratory such new elements, even before the designs of the ship were started. If the tests were successful on the new elements they could be incorporated in the designs, and the new ship would by this means be made more efficient. Under the present arrangement a naval officer is not justified in suggesting for adoption new things which have not been tried out in practice; and if the laboratory were constructed the designs would embrace the very latest ideas, and the United States would not fall behind in naval progress.

Through the use of the laboratory it would be possible for Congress, when it spent money on a naval program, to know that it would have fighting elements of the highest and best type, and this would be brought about by investigation and experimental work which would be conducted at a naval laboratory.

The civilian members of the Naval Consulting Board attached to such a laboratory would be in a position to consult some 30,000 engineers, members of the various societies which had selected them for the board; and if, for instance, a new laboratory wanted to know what the best bearings for a certain condition were, it could through its instrumentality consult engineers who had spent all their lives building bearings and who without a lot of experimenting give the results of their lifetime work.

One of the great virtues of the naval laboratory is that there would have been developed during peace times a corps of technically trained men who would be familiar with naval affairs and the present state of the development of the arts used in naval warfare whenever war occurred. They would be able immediately to direct their attention and that of civilian assistants to the creation of war devices. Its technical personnel would be the nucleus for the mobilization of scientists for war.

This naval laboratory should be for experimental research only, and it should be for the purpose of determining what is best for the Government to use for any particular purpose, as, for instance, a good engine for aeroplanes; and in such a plant Government experts would be daily working to ascertain what is best in everything that goes to make up that particular motor. Without the laboratory the Government is entirely in the hands of some manufacturer who has convinced it that a particular design of valve or cylinder that he makes is better than the one that some other fellow makes and is trying to sell to the Government. In an experimental plant the Government will be able to know through its own experts, who are working in the interest of the Government alone, what is the best form of valve or cylinder. This would be not because some manufacturer told it so but because they would know of their own knowledge.

It was also realized that discoveries of new things did not come up like mushrooms overnight as a rule, but that they are the result of a process of development. The experience of the Naval Consulting Board, as set forth in a later chapter, indicated this position to be sound.

The Navy also has problems which are not concerned with improving some one thing, but of changing some whole thing, and these problems are not the duty of anyone in civilian life. For instance, the question of whether it would be possible to get a sufficient quantity of oxygen from the sea by some device as to allow the operation of a submarine under the water indefinitely; in other words, to pump oxygen from the sea into a submarine and breathe it.

The Navy, by proper use of such an experimental laboratory, could get away from the idea that it is interested in what is finished and for sale on the market. All manner of problems in wireless operations of one kind or another would come within the purview of such a laboratory.

Another idea underlying the laboratory was to arrange so that money could be spent on research and development without first making an exact estimate of the cost, it being understood that experimental work is such that it either by a progressive development leads to the next step which it is necessary to attack in order to accomplish the desired end or else it is abandoned, and exact appropriations or estimates can not be made for this kind of work. It could experiment on new ideas without expecting that the experimenter would necessarily get a usable product out of each experiment. Its object would be to increase the knowledge of the Navy in regard to the arts and sciences experimented with. If the researches of the experimenter necessarily involved a study of the structure of an atom, that he would not be precluded from making this study if it led to an end result and was within the purview of the naval laboratory.

As a result of this necessity for a naval laboratory, study was made on the subject by a committee of the members of the board, consisting of Messrs. Edison, Baekeland, Whitney, Woodward, and Coffin. The following is an outline of the recommendations of the committee:

1. The laboratory should be located on tidewater of sufficient depth to permit a dreadnought to come to the dock. (*b*) It should be near but not in a large city, so supplies may easily be obtained and where labor is obtainable.

2. The laboratory should be of complete equipment to enable working models to be made and tested. There should be (*a*) a pattern shop; (*b*) a brass foundry; (*c*) a cast-iron and cast-steel foundry; (*d*) machine shops for large and small work; (*e*) sheet-metal shop; (*f*) forge shop for small and large work; (*g*) marine railway large enough to build experimental submarines of 1,500 tons; (*h*) woodworking shop; (*i*) chemical laboratory; (*j*) physical laboratory; (*k*) optical grinding department, etc.; (*l*) motion-picture developing and printing department; (*m*) complete drafting rooms; (*n*) electrical laboratory and wireless laboratory; (*o*) mechanical laboratory and testing machines; (*p*) explosive laboratory separate from main laboratory.

3. The building should be of modern concrete construction, with metal sills and doors, wire-glass windows, etc. Ample fire protection.

4. A naval officer of rank should be in charge. He should be specially fitted. (*b*) Under him should be naval heads of broad experience in laboratory methods and science in general—practical as well as theoretical men. They should not go to sea. (*c*) Under them should be staffs of civilian experimenters, chemists, physicists, etc. (*d*) Each subhead should have his corps of assistants and with shop facilities, without too much red tape. (*e*) There should be at

least two and possibly three shifts of men. *Time* should be the essence of the place.

5. Secrecy should be a governing factor. The place should be surrounded by a high fence and guard maintained at all hours. No visitors allowed.

6. Facilities should exist for enabling the inventor to assist in the development of the idea he has presented, provided he is a practical man.

7. The investment for grounds, buildings, and equipment should total approximately $5,000,000.

8. The annual operating expenses to be between $2,500,000 and $3,000,000.

NOTE.—For Mr. Edison's report, see Appendix, pages 230–232.

On March 15, 1916, Secretary Daniels, Mr. Edison, Dr. Baekeland, Mr. Coffin, Mr. Hunt, and Mr. Saunders appeared before the Committee on Naval Affairs of the House of Representatives, Washington, D. C., and subjected themselves to a thorough examination by the committee as to the purposes of the laboratory and its necessity. As a result, Congress incorporated in "An act making appropriations for the naval service for the fiscal year ending June 30, 1917, and for other purposes," approved August 29, 1916, the following provision:

EXPERIMENTAL AND RESEARCH LABORATORY: For laboratory and research work on the subject of gun erosion, torpedo motive power, the gyroscope, submarine guns, protection against submarine, torpedo, and mine attack, improvement in submarine attachments, improvement and development in submarine engines, storage batteries and propulsion, aeroplanes and air craft, improvement in radio installations, and such other necessary work for the benefit of the Government service, including the construction, equipment, and operation of a laboratory, the employment of scientific civilian assistants as may become necessary, to be expended under the direction of the Secretary of the Navy (limit of cost not to exceed $1,500,000), $1,000,000: *Provided*, That nothing herein shall be construed as preventing or interfering with the continuation or undertaking of necessary experimental work during the fiscal year ending June thirtieth, nineteen hundred and seventeen, as heretofore conducted under other appropriations: *Provided further*, That the Secretary of the Navy shall make detailed reports to the Congress not later than June thirtieth, nineteen hundred and seventeen, and annually thereafter, showing the manner in which all expenditures hereunder have been made.

Secretary Daniels, at one of the first meetings of the board, requested that the board immediately investigate the question of a site for the laboratory, and this was done. Among the sites investigated was one near the Naval Academy at Annapolis, Md.; one at Belleview Magazine, on the Potomac River a few miles below Washington; and one at Sandy Hook, just outside New York Harbor.

The members of the board could not agree upon a site; some members, including Mr. Edison, were firmly convinced that the site at

Sandy Hook was the one to be selected, while other members were in favor of the site at Annapolis or below Washington.

Then war was declared on April 6, 1917, and a combination of these two circumstances prevented the laboratory site from being selected and the laboratory being constructed. As a result the Navy had the money for a laboratory, and no doubt now that hostilities have ceased will use it for the construction of one at one of the sites mentioned.

The following are the reports on the laboratory sites which were submitted by the committee charged with the duty of investigating it: Majority report of the committee was in favor of establishing a laboratory at Annapolis, Md. Mr. Thomas A. Edison, however, made a minority report in favor of Sandy Hook, and Belleview Magazine, on the Potomac River near Washington, was thought of as a compromise. Belleview Magazine is situated about 4 miles below the Washington Navy Yard, on the Potomac River. It has good solid ground, good depth of water, and has room for an aviation field. North of this tract is an area of reclaimed land which has been made by extending the shore line, filling in from dredging and cutting in the Anacostia River.

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CHAPTER VII.

FUNCTIONS OF THE VARIOUS ORGANIZATIONS.

It will be recalled that the Naval Consulting Board had its organization meeting October 7, 1915, and was the pioneer organization dealing with inventions and scientific work for war purposes. It therefore, in the early days, covered a very wide field; but it was not long before, by its own acts, it had limited the scope of its activities.

For instance, the industrial preparedness campaign of the Naval Consulting Board led to the formation of the Council of National Defense, as has heretofore been pointed out, and the Council of National Defense adopted the National Research Council as its department of science and research. As pointed out in the chapter on the Ship Protection Committee, that committee was formed with the cooperation of the Naval Consulting Board, and one of its active members was a member of the Naval Consulting Board, Mr. A. M. Hunt.

The Ship Protection Committee took charge of all inventions in regard to protection of merchant vessels, and in that way relieved the Naval Consulting Board of certain activities in that direction.

The Nahant work of the Committee on Special Problems of the Naval Consulting Board was taken over by the Navy June 23, 1917.

In the summer of 1918 the Inventions Section of the General Staff was created by the following order of the War Department:

GENERAL ORDERS, No. 39.	WAR DEPARTMENT, *Washington, April 19, 1918.*

[Extract.]

V. Hereafter all communications relating to the submission of inventions to the Government for inspection, test, or sale received from any source in any office of the War Department, staff corps, supply department, or any headquarters in the United States will be referred directly to "The Inventions Section, General Staff, Army War College, Washington, D. C." Those desiring to present their ideas or inventions in person should be referred to the same agency and address. This refers to inventions of a mechanical, electrical, or chemical nature as distinct from suggestions or ideas or plans of operations to assist in winning the war. These last should follow their customary course. All men belonging to the service who have ideas for improvements in any of the material are notified to submit their descriptions of same freely and thus be of aid to the Government in the prosecution of the war.

[070 A. G. O.]

By order of the Secretary of War:

PEYTON C. MARCH,
Major General, Acting Chief of Staff.

Official:

H. P. McCAIN,
The Adjutant General.

The Invention Section of the General Staff, United States Army, took charge of inventions applicable to the Army. As the use of certain inventions overlapped in the Army and Navy—for instance, inventions in regard to projectiles, guns, etc.—this further narrowed the field of activities of the Naval Consulting Board.

The National Advisory Committee for Aeronautics looked after inventions in regard to aircraft, and the following act of Congress established it:

[Naval appropriation act (Public No. 271, 63d Cong.) approved Mar. 3, 1915.]

An Advisory Committee for Aeronautics is hereby established, and the President is authorized to appoint not to exceed twelve members, to consist of two members from the War Department, from the office in charge of military aeronautics; two members from the Navy Department, from the office in charge of naval aeronautics; a representative each of the Smithsonian Institution, of the United States Weather Bureau, and of the United States Bureau of Standards; together with not more than five additional persons who shall be acquainted with the needs of aeronautical science, either civil or military, or skilled in aeronautical engineering or its allied sciences: *Provided*, That the members of the Advisory Committee for Aeronautics, as such, shall serve without compensation: *Provided further*, That it shall be the duty of the Advisory Committee for Aeronautics to supervise and direct the scientific study of the problems of flight, with a view to their practical solution, and to determine the problems which should be experimentally attacked, and to discuss their solution and their application to practical questions. In the event of a laboratory or laboratories, either in whole or in part, being placed under the direction of the committee, the committee may direct and conduct research and experiment in aeronautics in such laboratory or laboratories: *And provided further*, That rules and regulations for the conduct of the work of the committee shall be formulated by the committee and approved by the President.

That the sum of $5,000 a year, or so much thereof as may be necessary, for five years is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to be immediately available, for experimental work and investigations undertaken by the committee, clerical expense and supplies, and necessary expenses of members of the committee in going to, returning from, and while attending, meetings of the committee: *Provided*, That an annual report to the Congress shall be submitted through the President, including an itemized statement of expenditures.

In addition to the duties indicated in the act above referred to, the committee acted in a special advisory capacity to the President and to the Congress in matters of general Government policy concerning aeronautics. Its organization is set forth in appendix.

NOTE.—For organization of the National Advisory Committee for Aeronautics see Appendix, page 232–234.

The War Committee of Technical Societies appeared on the scene, was adopted by the Naval Consulting Board, and its main function was to link up more thoroughly the membership of the engineering societies with the Army and Navy.

The War Committee was an organization formed June 27, 1917, and made up by two delegates from each of the following societies: American Society of Civil Engineers, American Institute of Electrical Engineers, American Society of Mechanical Engineers, American Institute of Mining Engineers, American Gas Institute, American Electro-Chemical Society, Illuminating Engineering Society, Mining and Metallurgical Society of America, American Society of Refrigerating Engineers, American Institute of Chemical Engineers, Society of Automotive Engineers. In its organization it was somewhat similar to the Naval Consulting Board, in that both boards were formed by elections from the membership of engineering societies.

The War Committee, however, was not limited in its activities to naval matters. It was partly supported by appropriations made by the Engineering Council, which is an engineering organization representing the four large engineering societies, namely, American Institute of Mining Engineers, American Institute of Civil Engineers, American Institute of Mechanical Engineers, American Institute of Electrical Engineers.

These larger organizations make contributions to the Engineering Council for joint work of the societies mentioned; and the Engineering Council, out of these funds so contributed, appropriated certain sums for the financing of the activities of the War Committee of Technical Societies. The four societies represented on the Engineering Council formed a nucleus for the formation of the War Committee, and gradually expanded by taking in additional societies, until there were 11 societies represented in its membership, by two delegates from each society. These societies contributed directly to the treasury of the War Committee certain sums for carrying on its work. The funds from the two sources above mentioned were not adequate to finance the War Committee, and the Naval Consulting Board very generously provided quarters to house the War Committee, and stationery and other office facilities.

Among the 30,000 members represented by the War Committee of Technical Societies were to be found specialists in every department of science and the industrial arts; hence these men, if provided by bulletins and correspondence with live, concrete problems relating to the war, could furnish ideas, suggestions, and inventions of a much higher and more useful class than were being received then from the general public, who had neither the initial training nor the information necessary to guide them in their work.

The committee was in a position to provide specialists who were competent to examine and furnish valuable reports on any of the various problems arising in the prosecution of the war by both land and sea.

As the volume of business between the War Committee of Technical Societies and the Inventions Section of the General Staff, United States Army, increased, the necessity for closer cooperation became evident, and the last of August, 1918, Capt. Lloyd N. Scott, assigned for duty with the General Staff, Inventions Section, was appointed liaison officer to the War Committee and the Naval Consulting Board.

On February 8, 1918, the War Committee of Technical Societies was appointed the civilian branch of the Information Section of the Ordnance Department, and after that date inventions and problems which it was considered civilian inventors could more readily solve were sent by the Information Section to the War Committee. This connection proved extremely useful and satisfactory to all parties concerned.

The chairman of the War Committee, Mr. David W. Brunton, was, in accordance with the following resolution, elected a member of the Naval Consulting Board:

Resolved, That this board approves the recommendation of its officers that the War Committee of Technical Societies be asked to recommend to the Secretary of the Navy a representative from the War Committee for membership on the Naval Consulting Board.

He later became the member in charge of the Naval Consulting Board in Washington, D. C., and in this capacity and that of chairman of the War Committee of Technical Societies was enabled to effectively coordinate the work of these organizations with the Inventions Sections of the General Staff, United States Army, and other organizations.

NATIONAL RESEARCH COUNCIL.

Some six months after the Naval Consulting Board was formed, when the relations of the United States with Germany were already tense, and the industrial preparedness campaign of the Naval Consulting Board was well under way, the National Academy of Sciences offered its services to the President to organize the scientific and technical resources of the country in the broadest and most effective manner, to solve the military and naval problems of the Nation.

The National Academy of Sciences was organized during the Civil War by a congressional charter which provided that "the academy shall, whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art." Under this provision the academy had acted since the time of its establishment as the official adviser of the Government on a wide variety of questions. During the Civil War its members dealt actively with military and naval problems of precisely the same type of those which would likely press for solution if the United States went to war.

The President, on May 11, 1918, issued the following Executive order:

The National Research Council was organized in 1916 at the request of the president of the National Academy of Science, under its congressional charter, as a measure of national preparedness. The work accomplished by the council in organizing research and in securing cooperation of military and civilian agencies in the solution of military problems demonstrates its capacity for larger service. The National Academy of Sciences is therefore requested to perpetuate the National Research Council, the duties of which shall be as follows:

1. In general, to stimulate research in the mathematical, physical, and biological sciences, and in the application of these sciences to engineering, agriculture, medicine, and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare.

2. To survey the larger possibilities of science, to formulate comprehensive projects of research, and to develop effective means of utilizing the scientific and technical resources of the country for dealing with these projects.

3. To promote cooperation in research, at home and abroad, in order to secure concentration of effort, minimize duplication, and stimulate progress; but in all cooperative undertakings to give encouragement to individual initiative, as fundamentally important to the advancement of science.

4. To serve as a means of bringing Americans and foreign investigators into active cooperation with the scientific and technical services of the War and Navy Departments and with those of the civil branches of the Government.

5. To direct the attention of scientific and technical investigators to the present importance of military and industrial problems in connection with the war, and to aid in the solution of these problems by organizing specific researches.

6. To gather and collate scientific and technical information at home and abroad, in cooperation with governmental and other agencies, and to render such information available to duly accredited persons.

Effective prosecution of the council's work required the cordial collaboration of the scientific and technical branches of the Government, both military and civil. To this end representatives of the Government, upon the nomination of the president of the National Academy of Sciences, will be designated by the President as members of the council, as heretofore, and the heads of the departments immediately concerned will continue to cooperate in every way that may be required.

WOODROW WILSON.

THE WHITE HOUSE, *May 11, 1918.*

The work of the National Research Council was financed by money received from the President's fund through the Council of National Defense and other sources.

Many of the other bodies, including the Naval Consulting Board, were advisory, but under the method of organization of the National Research Council it was in a position to do a specific thing. It was made the Department of Science and Research of the Signal Corps of the United States Army, and received Army funds from that source. It carried to the point of production many of the devices of the Signal Corps which concerned radio and other branches of communication, such as light and other means, which were of a highly technical and scientific character. After war was declared, comparatively large sums were placed at the disposal of the council for scientific experimental work. This work was done by officers of the Army and Navy, civilians in their homes, and civilians brought to Washington, and sent to the Bureau of Standards, the Western Electric and General Electric companies, and other institutions. It helped build up the scientific departments of the Army and Navy by bringing men to Washington whose scientific reputations it knew, and having them commissioned by the Army and Navy, where their services were most needed. Private funds were also put at their disposal by philanthropic individuals and the Carnegie Foundation and the Rockefeller Foundation.

As most inventions in modern warfare are based upon highly technical data and information, it was not long before the activities of the National Research Council led it into the field of the scientific subjects upon which naval inventions were founded.

The council was in a position, as a body having authority and responsibility, together with funds, to undertake organization work that would correlate the scientific information of the Allies with our own. As a result, they established a research information service with attachés in London and Paris; and on April 16, 1918, by circular letter No. 21, Admiral Sims, in command of the United States naval forces operating in European waters, created a scientific division of his staff and placed the scientific attaché of the National Research Council at its head. He called for the full cooperation of the officers connected with our vessels abroad.

By special memorandum No. 61, the chief of staff of Admiral Sims, Capt. N. C. Twining, called the attention of the staff to circular letter No. 21, and directed that certain naval officers keep in closest touch with the scientific attaché.

Through the channels thus created by the National Research Council information in regard to the scientific problems of the Navy and the scientific achievements of scientists in the United States passed. This was a benefit to the Navy operating in European waters, so that the National Research Council performed one of the functions that might have been performed by the Naval Consulting Board had it been organized with the definite authority and responsibility that was vested in the National Research Council. It will be recalled, in an earlier part of this book, that the Naval Consulting Board by necessity was organized without authority or responsibility, and was made an advisory body connected with the Secretary of the Navy's office.

The work of the National Research Council and the Naval Consulting Board was not coordinated, the result being that the Research Council built up an organization separate and distinct from the Naval Consulting Board. The council furnished information on technical and scientific subjects to the Navy, as well as other branches of the Government, and brought forth inventions and improvements on the highly technical matters involved, without coming into intimate contact with the Naval Consulting Board.

The result of this differentiation and specialization of functions was that the Naval Consulting Board finally became the Inventions Board for the Navy, and later, through appointment by the Council of National Defense, for the United States Government. As such it passed upon, as hereinafter described, inventions received from the public. Its members, many of them eminent inventors, devoted themselves individually to the development of devices of their own invention.

At a meeting of the Naval Consulting Board, held on February 10, 1917, the following resolution was passed:

> That the Secretary of the Navy be informed that this board holds itself at the service of the Department of War or of the Council of National Defense to act as a board of inventions, or in any other capacity which may be of use to the Government in the present emergency

Copies of this resolution were forwarded to the Secretary of the Navy and to the Council of National Defense.

On February 15, 1917, the following resolution was passed by the Council of National Defense:

> Whereas the Naval Consulting Board has informed the Secretary of the Navy that it holds itself at the service of the Department of War or the Council of National Defense to act as a board of inventions, or in any other capacity which may be of use to the Government in the present emergency:
>
> *Be it resolved*, That the Council of National Defense hereby express its appreciation of this action on the part of the Naval Consulting Board;
>
> *And be it further resolved*, That the council call upon the board for advice and assistance whenever the occasion therefor shall arise.

At the time of the armistice the summary of the situation in regard to scientific research and invention would be about as follows:

The Naval Consulting Board acted as a board of inventions for the Navy and the United States Government, and received hundreds of suggestions weekly from inventors throughout the country, principally for Naval use.

The Inventions Section of the General Staff, United States Army, received inventions from the public to be passed upon for Army use.

The Ship Protection Committee of the United States Shipping Board received ideas and suggestions from the public to be passed upon for use on merchant ships.

The National Advisory Committee for Aeronautics received ideas and suggestions from the public and passed upon their practicability for aircraft use.

The National Research Council acted as the department of science and research of the Council of National Defense and the Science and Research Division of the Signal Corps of the United States Army. This corps had charge of all means of communication in the Army, including radio. The ramifications of National Research activities led it into naval aviation, naval communications, radio work of all kinds, as well as submarine detection. There was thus a great overlapping of spheres of activity in the scientific work which could have been avoided by a proper organization.

The Naval Consulting Board fostered and nurtured many early organizations which later became great Government structures, and its members, as individuals, served on the National Research Council and other organizations.

CHAPTER VIII.

INVENTIONS FROM THE PUBLIC.

All bureaus of the Navy and departments of the Army, and most of the governmental departments in Washington, received ideas, suggestions, and inventions in great numbers from the public. Long before we entered into the war these communications to the Navy Department increased manyfold; and, as pointed out in the chapter on "Organization," there was created an inventions office attached to the office of the Secretary of Navy, through which all inventions that came from the public and directed to the Navy Department were handled directly in this office. Rear Admiral Smith, who had charge of this office, considered many of these inventions.

The Naval Consulting Board also received thousands of inventions from the public.

On April 6, 1917, at the time the United States entered the war, the work of examining inventions was being carried on by the secretary of the board, Mr. Thomas Robins, with the assistance from other members of the board, and his own private office staff. A tidal wave of inventions, however, deluged the office at that time, and it became necessary to expand the force and organize the handling of inventions from the public on a business basis. By June the office force had been expanded to 12 office employees and 8 examiners, besides the executive work done by the secretary of the board, Mr. Robins, and his two assistants. By August, 1917, the board was obliged to take a suite of five offices to replace the limited office space which it had used prior to that time.

The quantity of incoming material was greatly stimulated by articles which appeared in various publications describing the work of the Naval Consulting Board, and by every new disaster to merchant vessels which was accompanied by great loss of life.

At the request of the secretary of the board, Lieut. Charles Messick, U. S. N. R. F., was detailed to the office and put in charge of organizing the office force and machinery for handling inventions. At the time of the armistice Mr. Alan T. Burleigh had charge of this branch of the work. Later four yeomen were also detailed to this office and assisted in handling the work, and following is a list of the staff utilized:

Five technical examiners of inventions, three junior examiners of inventions, personal assistant to the secretary, head file clerk, chief stenographer, three stenographers, three file clerks, switchboard operator, four yeomen who performed miscellaneous duties.

At the time of its greatest activities, in 1917, this force during a single day handled some 600 letters, which really meant that something slightly less than that number of individual cases were given attention.

The method of examination was as follows: A preliminary examination was given by the junior examiners; if an invention appeared to have the slightest merit it was turned over to the senior examiners for further and deeper consideration. The senior examiners then sent to the various chairmen of the committees of the Naval Consulting Board those inventions which had special merit for their expert opinions. The chairman of the committee then sent the inventions to each member of his committee for comments and suggestions. The invention came back to the chairman with annotations of each member of the committee. The report of the committee was then made up by the chairman after a meeting of the committee, and either sent to the secretary of the board or presented to the board in open meeting, according as the circumstances seemed to warrant. If the report was made to the open board, it was usually done where an appropriation was necessary in order to either test the invention or to develop it.

At the meeting of the board the chairman of each committee was called on for his report, and if he wanted an appropriation for conducting experiments he would ask for the appropriation at that time. Board members asked the chairman of the committee questions to satisfy themselves on the different points involved in the invention, and general discussion would ensue. A vote would then be taken, and if a majority were in favor an appropriation was approved by the Secretary of the Navy. The chairman of the committee which had reported favorably on the invention, and which had thus received an appropriation, would appoint one or more members of his committee to conduct the experiment with the invention. The chairman of the committee would frequently ask the member knowing most about a certain invention to address the board; and if an appropriation was made the chairman usually appointed this man to supervise and conduct the experiment, with authority to associate with himself any outside or inside talent that he might wish. He would make necessary expenditures and do the necessary traveling and pay the necessary traveling expenses of the inventor and such outside civilians as he might enlist to help him on his experiments. He was also given power to make the necessary arrangements with the Army, Navy, or outside concerns to make the experiment, and would keep his chairman advised during the progress of the work. The chairman usually witnessed the final test of the device before the experiment was completed, so that the report which was made on the device was made not only by the man vested with authority to conduct the experiment, but also by the concurrence and indorsement of the chairman of the committee.

The report which was made would then go to the open board, and if a favorable one would be turned over to the bureau of the Navy Department interested in the device, through Rear Admiral William Strother Smith, liaison officer between the office of the Secretary of the Navy and the Naval Consulting Board.

Inventors who had devices of merit appeared before the committee in charge of the particular subject under which the device came, and when advisable they were invited to appear before the entire board.

It was soon found that inventions received could be readily classified, and this greatly facilitated the handling of them. As an indication of the general classes into which the inventions fell, the following estimate of the total in each of the larger classes has been made based on the cross indexing of some 30,000 out of 110,000:

Submarines	4,007
Ideas to combat submarines	2,072
Submarine destroyer	1,517
Submarine detectors	691
Submarine destruction	1,180
Submarine detection	895
Ship protection	9,420
Nets	3,570
Shields	2,486
Plates	684
Guards	403
Armor	136
Submarine bases	233
Boats	2,053
Bombs	1,986
Camouflage	99
Convoy	88
Crews	136
Engiues	1,572
Forts	151
Guns	1,720
Life-saving devices	814
Mines	1,605
Motors	629
Nets	943
Periscopes	592
Power	351

Propellers	999
Ship protection deflectors	125
Fences	74
Fenders	81
Hull	229
Mats	218
Torpedoes	2, 571
Torpedo catcher	643
Aerial torpedo	462
Torpedo deflector	751
Vessels	4, 218
Aircraft devices	3, 966

In the beginning the board was without knowledge as to the reaction of inventors with whom it entered into correspondence, and therefore stated specific reasons for rejecting their inventions. This precipitated a voluminous correspondence with inventors who became dissatisfied and wanted to argue the question of rejection, and as a result, the board finally adopted the policy of not disclosing specific reasons for rejecting inventions, as by written communications it seemed almost impossible to convince any inventor, however worthless his invention might be, that it was valueless.

Inventors, however, who were located near one of the offices of the board, and had an opportunity to talk with the examiners, were more likely to be convinced and see wherein their devices were either old, inapplicable, or defective in some way. Inventors came to the office from every walk of life, and were rich and poor, cultured and uncultured; but the majority seemed to be persons of limited culture.

The offices of the board were at 13 Park Row, New York City, and examiners and members of the board were in touch with one of the largest navy yards in the United States, situated at Brooklyn, in the third naval district. Lieut. Messick, who was detailed to service with the board, had access at all times to conference with the officers on active duty and acted as liaison officer between the civilian examiners and the operating forces of the Navy.

Although no actual statistics are available as to what proportion of inventions were sent to the committees of the board for consideration, it has been estimated that not over one in a thousand was worth sending by the examiners to the various committee of the board for consideration.

Of the 110,000 which came to the board and the Navy Department from the public, approximately 110 thereof were of requisite standard to be submitted to committees, and of these 110 but 1 was put into production, although several others were developed and might have later been used.

It is understood that the Inventions Section of the General Staff, United States Army, received 25,000 ideas and suggestions from the public, of which but 25 were of value.

The experience of the French Government was similar to that of the Naval Consulting Board in regard to the inventions received from the public.

The superior inventions commission, which was created by decree on August 11, 1914, received and examined between August, 1914, and November, 1918, 44,976 proposals, out of which 1,958 were retained by it, which is about 4.3 per cent of those received.

The administration of inventions was created November 13, 1915, and between that date and the armistice, the superior inventions commission, above referred to, turned over to the administration of inventions 35,313 proposals, out of which 1,654 (4.6 per cent) were transmitted to the officers of invention under the administration. Of these 1,654 which had been submitted to the officers for study, 781 were worked out in detail and were susceptible of immediate application, and were transmitted to the technical bureaus interested. Therefore about 2.2 per cent of the 35,313 inventions were turned over to the technical bureaus.

In considering the inventions received by the French Government it should be noted that for a great length of time it had maintained large standing armies, as well as factories for the production of war materials. It is therefore not surprising that the high grade of material received by them was of a somewhat higher character than that received by the Naval Consulting Board.

The Under Secretary of State had, under his direct control, the entire work of the munitions ministry, and was thus entrusted with the close and cooperative administration of this entire field of work.

The impressive thing about the French schemes for handling inventions were the facilities which they accorded for study and technical experiment. The Naval Consulting Board had no laboratory, no place to conduct experiments, and no staff to carry them on. Facilities which were used were those that were open to any citizen who could pay for the services that commercial concerns were willing to render. This, of course, is with the exception of large laboratories and shops which individual members of the board owned and controlled. Had the laboratory been constructed, for which Congress made an appropriation, this would all have been remedied.

Although a board of inventions and research which the British Government created for the handling of research and inventions during the war received up to July, 1918, some 53,000 inventions and proposals, of which 36,000 related to the submarine, the mine, and naval engineering, 13,000 to ordnance, and about 4,000 to aircraft, yet no figures are available which indicate what proportion of these ideas were adopted by the British Government.

The organization of the board of inventions and research of the British Government was somewhat different from that of the Naval

Consulting Board. It was composed of a central committee of three members, which consisted of the Admiral of the Fleet, Lord Fisher of Kilverstone, G. C. B., O. M., G. C. V. O., LL. D., president; Prof. Sir Joseph J. Thomson, O. M., F. R. S.; and the Hon. Sir Charles A. Parsons, K. C. B., F. R. S. The heads of the technical departments of the Admiralty were associate members of this committee on the understanding that these officials should only be summoned to meetings when specially required.

A consulting panel of scientific experts was also part of the organization. It was composed the following members: Prof. H. B. Baker, F. R. S.; Prof. W. H. Bragg, F. R. S.; Prof. H. C. H. Carpenter; Prof. Sir William Crookes, O. M., pres. R. S.; Mr. W. Duddell, F. R. S.; Prof. Percy F. Frankland, F. R. S.; Prof. Bertram Hopkinson, F. R. S.; Sir Oliver Lodge, F. R. S.; Prof. W. J. Pope, F. R. S.; Prof. Sir Ernest Rutherford, F. R. S.; Mr. G. Gerald Stoney, F. R. S.; Prof. R. J. Strutt, F. R. S. Sir Dugald Clerk, K. B. E., F. R. S., and Sir Richard Threlfall, K. B. E., F. R. S., were subsequently added.

A secretarial staff of the board dealt with the preliminary sifting of the proposals from inventors and others and handled the arrangements for special inquiries, experiments, and the financial side of the work.

The board soon determined that the most important function that it could perform was to first concentrate expert scientific inquiry on certain definite problems the solution of which were of importance to the naval service. Second, to encourage research in the direction in which it was probable that results of value to the Navy might be obtained by organized scientific effort. Third, to consider schemes or suggestions put forward by inventors and other members of the general public. In other words, the experience of this board was similar to that of the Naval Consulting Board in that the best results were obtained by concentrating scientific inquiry on definite problems and encouraging research in definite directions rather than by relying upon the schemes or suggestions from the public. This was so, even though flag officers and senior officers of the Royal Navy were invited to collect suggestions from the service afloat and forward them to the board for consideration.

The board ran along with this organization until January, 1918, when it was found desirable to organize more completely the necessary experimental and research work and bring to bear upon it sufficient scientific and technical knowledge through insuring a closer contact between the naval officers, the scientists, and the engineers. The department of experiment and research was therefore founded at the Admiralty. The director of this department, Mr. Charles H.

Merz, M. Inst., C. E., was appointed a member of the central committee of the board of invention and research and this board continued to investigate and advise upon ideas submitted by the public; and the department of experiment and research dealt with the actual experimental and research matters dealing with specific problems, which arose in the course of naval work. It organized an effective link between the Admiralty and the leading scientists and the great manufacturing organizations of the country.

Finally, on the 31st of December, 1918, the board of inventions and research was abolished and the functions of the board and of the department of experiment and research were merged in a department of scientific research and experiment.

In other words, the evolution of the handling of inventions in Great Britain went through very much the same course that they did in this country. There was first the creation of a board of illustrious scientists and inventors who met weekly or monthly. The actual routine of the board, however, was carried on by a secretarial staff who dealt with the preliminary sifting of proposals from inventors and others. The central committee and the panel maintained touch with the six sections and subcommittees which had been appointed to deal with the several subjects. The department of experiment and research was then organized at the Admiralty to effectively deal with the directing and coordinating of the work on special problems.

They therefore found it absolutely necessary to create an organization in the Admiralty with full authority and power to deal with all aspects of scientific and inventive problems in a businesslike and efficient way; not relying upon voluntary contributions of the public but rather the teamwork of scientists, each contributing something toward the solution of her perfectly definite problems.

The experimental work in Great Britain was undertaken in the naval establishments which were instituted in various parts of the country and by scientific laboratories in the principal towns frequently connected with manufacturing establishments, so that Great Britain also had her difficulties, for the reason that she apparently had no central laboratory such as was contemplated for the Navy when Congress made its appropriation for that purpose.

The experience of the Naval Consulting Board indicated that the inventions of isolated inventors, who did not have access to the naval information and whose single source of information came from newspapers and public prints which were under heavy censorship and which did not divulge much technical information, had little or no value.

In order to get results from inventors the most essential thing is to get information to them. This involves practically the organization of a correspondence school for inventors, with all of its inherent difficulties, among them being the distributing of confidential information which may ultimately reach the enemy.

As the whole progress of civilization is dependent on invention, some instrumentality, either private or governmental, should be created to supply to groups of mechanics, scientists, and others of an inventive turn of mind instruction and information in regard to the present state of the particular arts which they are trying to improve. Sources of information should be put at the disposal of would-be inventors from which they could obtain ideas and information so that their inventions would be built on a firm foundation of accurate knowledge.

On account of the low grade of material received from the public and the diagnosis of the board that this was on account of the fact that the public was not informed on the problems confronting the Navy Department, a campaign for the spreading broadcast of knowledge in connection with the particular subjects in which the Navy and the public were interested was undertaken.

Through the cooperation of the War Committee of Technical Societies two bulletins were distributed to the public, one on "The Enemy Submarine" May 1, 1918, and the other on "Problems of Aeroplane Improvement" August 1, 1918. These two bulletins were preceded by a bulletin issued by the Naval Consulting Board on July 14, 1917, on "The Submarine and Kindred Problems," and it was the experience gained through this bulletin that actuated the board to send out the subsequent bulletins with the cooperation of the War Committee.[1]

The results obtained from the issue of these bulletins were to a certain extent of a negative character in that the bulletins reduced the number of incoming suggestions that were of no value and raised slightly the average quality of ideas and suggestions which were received thereafter.

The majority of the suggestions received by the board from the public sought to reach goals which had been the common property of human minds and the students of the respective arts concerned for a long time. If the goals could have been reached there would have been no difficulty in solving the problem. It was a question of accomplishment. The inventors formulated the goal to be achieved, but did not show how to reach it. Many inventions were not in accordance with the laws of nature as known. A clear understanding of the inventions was almost in all cases difficult because of defective expression on the part of the inventor.

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[1] See Appendix, pp. 252 to 286.

Many of the inventors suggested something already in use, or that had been used and abandoned for the sake of a better thing. There was a great lack of knowledge on the part of inventors as to devices already existing that served the same purpose proposed by the inventor. Most of the inventors did not have knowledge as to the behavior of a boat at sea, and did not know what the conditions on shipboard were when it encountered a bad storm that would wash the decks of the ship. They failed to realize the action of salt water as a corroding agency. They failed to realize that there was a limit to deck space and that there was a limit to the amount of equipment that could be placed on the decks. And they also failed to realize the value of spacing on a ship and the fact that you can not put a ton of one thing in a position where there is a ton of something else; that everything that goes into a ship means the exclusion of something which may be more valuable. Inventors also failed to understand that even if a device were good, it would necessarily have to pass through a long experimental period before it could be adopted, and that after adoption all the men on board the ship that would operate it would have to be instructed as to its operation. However perfect a machine may be in the hands of the inventor it might not work well in the hands of the ordinary man on shipboard.

Instruction books, regulations, and drill practice have to be arranged for before a new machine or improvement can find its place on shipboard, already overloaded with more mechanical devices than the average man is capable of handling quickly.

A new and untried device would work no particular injury if it found itself on a farm or in a factory, but on shipboard it is so much dead-weight if it is not used, or else it calls upon the services of men already overloaded with responsibilities. It is very difficult to produce a device which is foolproof, and a machine that is not foolproof is one to be carefully scrutinized before placed on board a ship.

Take, for instance, the inventions in regard to aeroplanes. Most of the proposed inventions in regard to aeroplanes were for attachments or improvements, such as details of the motor adjuncts, or a carbureter suited for high altitudes, or a supercharging device; there were also two general classes of parachutes, one attached to the aviator and one to save the whole machine. Three-fourths of these inventors were not familiar with the principles of aero dynamics. Probably not over 2 per cent had had any practical experience in flying. Many of the things which were proposed would have been useful if they could have been produced, but there were mechanical difficulties which the inventor did not solve.

Most of the inventors did not understand the present state of the art which they sought to improve.

Inventors suggested the same ideas over and over again, which were duplications of things already suggested, and where there were not duplications, in many cases they had been anticipated by existing inventions. The same mistake was made over and over again by different inventors. Their minds seemed to work in the same channels and along the same lines. They thought of something that it was desirable to accomplish and suggested that it be accomplished, ignoring the difficulties involved in accomplishing it.

Most of the inventions submitted were in the nature of ideas and not concrete devices. For instance, a man would send in such a technical thing as a helicopter and with a pencil drawing, but without relative dimensions of the different parts, weights, etc. The success or failure of such a device depends on these factors.

Inventors did not seem to realize how large a balloon was required to lift a given load. The inventor would picture a small balloon holding up an aeroplane with broken wings. He did not realize that if the balloon were sufficiently large to hold up any considerable weight it would be large and impracticable.

Inventors suggested aeroplane propellers which they claimed would have three or four times the efficiency of propellers in use, but they did not know the present relatively high efficiency of propellers.

In examining the mass of material submitted, one is impressed with the fact that the inventors submitted ideas poorly conceived without plans showing details. The idea was not put into such tangible shape that it could be utilized.

The results of an analysis of the ideas and suggestions sent in to the Naval Consulting Board, set forth below, indicates that by mental process alone, without experimentation, and without familiarity with the subject matter of the art, very little need be expected in the way of valuable inventions.

Only those men on the frontiers of scientific development and on the frontiers of development of the various arts concerned in naval warfare would be at all likely to discover anything that was new or could be used by the Navy Department. On the assumption that invention is the conscious striving of an inventor toward a certain end result, it is necessary in order to make a successful invention for him to know the present state of the art he is seeking to improve, the difficulties surrounding that art, and the ideal to be achieved. Applying this test to most inventions, it was found that the majority of the inventors did not know the present state of the art which they were seeking to improve and, as a matter of fact, knew very little about the art and its difficulties. They did not know what was desired; ideals which were the obvious ones, which every man who reads the newspapers would think about, were the ones which they worked on. For instance, hundreds of suggestions were sent in with regard to nets and plates for protection of ships. As a rule, however, the inventor did not know anything about the skin resistance of a plate in its passage through the water, or the resistance offered by a net, and the decrease in the maneuvering ability of a ship brought about by its use. Many sought to stop torpedoes by various means without knowing that many torpedoes are designed to explode when stopped or are deflected from their course.

Many inventors without knowing the limitations of the action of a magnet upon steel or iron suggested the use of magnets at such distances as to make them impracticable. In other words, if the inventors had, before sending in their suggestions, gone to any public library or looked up the subject which they were seeking to improve in one of the standard encyclopedias, they would have spared examiners of the Naval Consulting Board an infinite amount of work.

The following estimates are based on the results of the examination of samples impartially taken of the 110,000 ideas and suggestions received from the public by the Naval Consulting Board and the Navy Department.

Seventy-five per cent: Approximately this number of inventions were shown to be an amateurish mental attempt, without any experimental work on behalf of the inventor, to solve a problem, with only part knowledge of the facts, particularly the highly technical subject matter involved, and without knowledge of difficulties surrounding its solution. In this 75 per cent the idea was not based on observations but rather on deductions from what were thought to be facts. They were creations of the inventor's mind, not reduced to concrete form, showing that the inventor had little or no experience with the subject matter of the invention.

Twenty-five per cent: There was some merit in this remaining number, and they seemed to understand the subject matter of the invention; but of this 25 per cent the following classification was made: 16 per cent were old, or were no improvement over present devices, or were not so good as present devices; 7 per cent were impracticable; 1 per cent Army inventions; 1 per cent inventors still working on development.

Forty-three per cent were written in longhand and 47 per cent were typewritten (in these the diction was that of a fairly well educated person); 11 per cent were written in longhand, uneducated diction; 57.2 per cent inclosed sketches poorly made, or none at all; 8.2 per cent were commercial circulars, processes or patents, of which a small percentage were in commercial use; 13.6 per cent seemed to have made experiments with their devices; 1 per cent were apparently from crazy persons.

Most of the ideas suggested seemed to be actuated by patriotic and altruistic motives, and not from any idea of gain to the inventor, although this was not always the case. The following extracts from letters taken at random show the general class of material that was submitted.

"Dear Sir—I am an old miner, past 70, sitting in his lonely cabin this stormy day studying how he could do his bit. Have been thinking about the unsinkable ship. I have drawn rude diagram of a ship sawed in two. If I can give an idea that would help I would be awful glad. No. 1 for the soldiers, No. 2 hold to be cut up into watertight compartment, No. 3 to be filled with some material that would protect the steel bottom. Should a torpedo explode underneath it. No. 4 will act as a keel or centerboard in an old-fashioned yacht. I would recommend the vessel should be made wide. There would be more show for the torpedo to deflect should it strike high. Hoping some of your experts may get a good idea from this. Very respectfully * * *."

"I have done no experimental work on the idea presented to you regarding the * * *. The principle was reached by a speculative process, and in my belief quite inerrable, and having followed the light of reason thru a series of phenomena, and emerged from them with a purely intellectual conclusion, I considered it my duty to bring it to your attention, in the hopes that the Navy, finding it plausible, would have that conclusion brought to an experimental test, for our country's defense. I will try to reach the confines of the subject by more study, and later on produce a model * * *."

"Dear Sir—Please excuse my liberty. I have an *Idea* that may be of Benefit to the "Navy" also to the "Merchant Marine." It is in form of Protection against Submarine attack. I will *submit Idea*, &, if *adopted* I am to receive a liberal payment *for same*. Were I Financially able I would not ask a Cent for any means whereby it would help my Country. I am Respectfully Yours * * *."

"I am sending the plans of a * * *. There are a few minor details left out, but I know you and your expert mechanics can find what is needed. I have seen different models of * * * with every kind of motor power except steam. Knowing what steam can do as I fired boilers for four years I thought of the * * *. Motor trucks could convey coal and water behind * * *."

"Enclosed you will find rough sketch to bear out my idea, which is to build * * *."

"I am writing you merely to offer a suggestion, which may or may not be practical. My idea is to manufacture a * * *. This * * * is to be of such weight as will remain afloat * * *." (No information as to how it is to be constructed or operated.)

"I am submitting this without detail * * *."

"Can there not be constructed a * * *."

"Enclosed is a rough sketch of * * *. The advantage of this are * * *." (No details of device ever having been made or how it could be made.)

"Dear Sir—I have several ideas on aeroplanes, and I have always wanted to try them out, but I have been a working man and have a large family I did not save the money to get the things I needed. Now it will not cost much to try the same. I will be glad to explain them to you."

"Gentlemen—I see by the papers that you are expecting suggestions on the submarine menace. I would suggest the using of a * * * ." (No drawings, or details, or specification attached and the inventor does not understand the fundamental principles.)

"Why could not * * * similar to * * * be used on floats? I am sending you this thinking the idea might be worked out some way and be of some use to you."

"Dear Sir: I am sending you a rough sketch, of a plan to save our merchant ships, from being destroyed, by the deadly torpedo of the German Submarine. Altho this plan may not be practical, and there may be similar methods used; I have never heard of such. And having the interests of my country, at heart I feel it is my duty to submit my plan for your consideration. And if such a plan is practical and is put into use, and proves to be what I sincerely hope, a means of saving our Ships from destruction, and the lives of American citizens on the high seas, then I shall feel that I have rendered my country a service worth while. My plan is to have a number of * * * around the ship, and a sufficient distance from the ship to stop the torpedo and explode it away from the vessel. These * * * should extend from below the water high enough above the surface to stop the torpedo and still not be observed by the submarine crew. Hoping this plan will be of service, I am Yours very truly * * * ."

"Dear Sir: I am too old and with too much affliction to be of any very active service to the Nation but not too old to think and I been thinking about those torpedoes that cause so much destruction by coming in contact with some hard solid substance and which I know but very little about it but if coming in contact with a hard solid substance is the cause of the explosion why not try something soft and springy on the hull of the vessel say springs surrounded by cork and rubber that might cause the torpedo to bounce off. Am just making a suggestion altho it may not be worth anything."

The conclusion to be drawn from the character of the material which came to the Naval Consulting Board was that a thought was suggested to the mind of the inventor by reading in a newspaper or other source of information certain difficulties surrounding the problem of a submarine, for instance, and next the leaping of the mind of the inventor toward some kind of a solution based on such faulty information of the subject as he had before him. In other words, it was the first thing which came into the inventor's mind in regard to the matter, without knowledge of the surrounding facts. There were waves of this information which went broadcast through the country, and corresponding waves of inventive ideas and proposals which came back to the Naval Consulting Board.

The examiners of the Naval Consulting Board finally became so skilled in this matter of prognosis that after the torpedoing of a merchant ship which was given wide publicity in the papers they would remark, "Well, we will have an increase in ship-protection devices, nets, and plates as a result of that sinking," and in a few days there would be an increase in the number of such ideas and suggestions received by the board.

It is not likely that a man having lack of information, in the first place, and lack of experience with maritime matters, in the second place, will invent devices of any importance. A conclusion is no better than the facts on which it is founded, and an invention is also no better than the facts on which it is founded. Faulty assumptions by an inventor lead to a faulty invention.

It is often said that inventions come like a flash of inspiration and without any aid from experience or education; but the results of an analysis of materials received by the Naval Consulting Board would indicate that although there may be a flash of inspiration, yet that flash is no better than the information and experience on which it is founded, and that if the information and experience is faulty, the flash of inspiration is of no value.

No doubt the inventor who creates an invention founded on faulty premises feels the same sensation of actual creation as the man who creates an invention founded on right premises. Both, no doubt, get the same sensation of pleasure from the act of creation, but on the one hand one is valuable, and on the other hand one is not valuable.

Instruments of naval warfare are of such a technical character that any man devoting himself to their improvement must have a high degree of technical training. It is a work of specialization. The men who are developing an invention are more likely to make discoveries and improvements than those who are not familiar with the subject matter.

As an example, take the case of Dr. Coolidge, mentioned in the chapter on the "Special Problems Committee," who, while experimenting with the Broca tubes, found that when the coupling of rubber between two pieces of metal was disconnected he got better results than when the metal was present, and deduced from this observation that rubber was a better substance to use in the detection of sounds under water than metal. He was working with a particular device with which he was familiar, and was seeking to overcome a difficulty, and the result was a discovery and an invention.

An invention has been well said to be the conscious striving to achieve an end result which is pictured in the inventor's mind. In order to accomplish this end he must know the present state of the art which he is seeking to improve, the difficulties encountered in using present devices and equipment, and the ideal to be achieved. Discoveries of new properties of matter may lead, by the use of interpretative intelligence, to the creation of new inventions without the arduous labor involved in creating something new by above method; but most of the problems confronting the Navy required laborious effort to achieve the end result desired.

The following illustrates the improvement of an art through discovery:

A new insulating material was said to have been discovered in the following manner: A workman noticed that he burned his hand whenever he touched the steam pipes in the lower part of a tank which he was cleaning and did not burn his hand when he touched those in the upper part of the tank. This came about through the fact that in the tank the carbonate of magnesia tended to float and the carbonate of lime tended to settle, and in the upper part of the tank the carbonate of magnesia predominated, which coated the pipes and insulated them.

If this same workman made the same observation to-day, now that carbonate of magnesia is largely used as an insulating material, he would have made a discovery which to himself would be just as real as to the original discoverer, but in the one case a valuable contribution was made to the arts and in the other it would simply be a rediscovery of something old.

Take the X ray, for instance, developed many years ago; there was no doubt, no design, or thought in the mind of the discoverer of this ray of a scheme whereby you could see through the human body. Seeing through the body was incidental to the investigation of the subject matter with which he was working.

Another example of an invention said to have been made by accidental discovery was as follows: The man who put calcium carbide on the market was looking for a process to produce aluminum. During his experiment calcium carbide was being produced and he thought nothing about its value. One day an associate stumbled and dropped a bucket of water over a pile of refuse. Gas immediately arose from the reaction of the water on the mass of material on which it had dropped. The experimenter, being a chemist, discovered that he had acetylene gas; in other words, he was producing something of a commercial value.

On the other hand, Mr. W. G. Ruggles, who invented the Ruggles orientator for testing the physical and psychological characteristics for candidates for the flying service, which was developed under the auspices of the Naval Consulting Board and adopted by the Navy Department, came about in another way.

This device was conceived in the following manner: As a child Mr. Ruggles discovered that when he was upside down he could not direct his muscles the same as when he was upright, and when he came to study aviation with the idea of actually flying, he became interested in the problem of trying to determine whether he was fit for the Aviation Service. He had lived with surgeons and was familiar with their work, had done a great deal of gymnasium work, and had some idea of surgery and the peculiar ways the human body is constructed. He had a leaning toward mechanics, and this gave him some mechanical ideas, and when these ideas were fused together and focused upon the problem of determining whether he was properly fitted to become an aviator, there was a cross fertilization of ideas and he made an invention which incorporated physiological, electrical, and mechanical features.

The inventor, in these cases, was working with the materials out of which his invention grew, and his invention was either incidental to his work, as in the case of the X ray, or accidental, as in the case of carbonate of magnesia or calcium carbide.

The experience of the Naval Consulting Board in dealing with inventions received from the public makes it safe to say that there is little likelihood of anything of value being produced by one not working with the materials, or at least familiar with them and the state of the art. It is also very unlikely that anything of value will be produced by mental dreaming without physical effort by one who knows nothing of ships, shipping, or the instrumentalities used in naval warfare, and who is not in a position to make experiments.

Many of the most important inventions in these days come about by teamwork, and the development of listening devices at Nahant and New London, as set forth in the chapter on that subject, was a type of the application of industrial organization to the achievement of certain results, which are brought about by the combined efforts of many brilliant minds. The modern engineering undertakings and research work are so vast that they far exceed the capabilities of any one individual, and it is only by the united efforts of many brilliant minds that results can be obtained. Each step or development usually offends some proven practice, and it is only by the utmost ingenuity and painstaking study of many minds that these difficulties are overcome.

The progress of the arts and sciences is largely brought about through the accumulation of facts in regard to the physical and mechanical properties of matter. Myriads of facts must be stored up, which are available for those working in the particular arts and sciences concerned, and the modern inventor must have access to this data in order to round out his invention. For however wonderful a conception he may have in his mind, he will in the course of development come to a point where he stumbles for want of knowledge in regard to a particular fact. It is then that he calls on those having made specialties of certain things, and endeavors to get by the point at which he is obstructed. If that information does not exist, he is then obliged to either make investigations and research on his own account, or wait until the art in that particular line has developed to a point where he can overcome the obstacle which has obstructed him. This is demonstrated in the case of the aeroplane and the work of Prof. Langley, of the Smithsonian Institution. Prof. Langley had worked on the laws of flight and made a machine which did not fly successfully at the time of the original experiment, but was later flown after his death, when internal combustion engines were placed in it that were lighter than the propelling power which he was obliged to use in his experiment. Each increase in knowledge therefore reacts on every other art, and the process of scientific advancement in inventions come through the cross fertilization of one art upon another.

To those who are working on the frontiers of naval technical matters there is no dearth of inspiration as to what they would like to accomplish. But they realize that there must be a selection made of the most promising ideas and the energy of the engineers expended on them, rather than on all sorts of devices of minor importance. In other words, as it has been tersely said, there is no shortage of inspiration but there is a shortage of perspiration. The inventions that were submitted to the Naval Consulting Board had very little perspiration in them, and were mostly all, as pointed out above, faulty inspiration, which was the outgrowth of faulty information.

Even members of the Naval Consulting Board, whose training was such as to make it possible to invent new devices for the improvement of naval equipment, did not do all they could have done in this particular, on account of lack of information as to the requirements. If, in connection with this board there had been organized a force of critical inspectors whose duty it should have been to inspect and constructively criticize equipment of the Navy from the standpoint of its defects, and possible improvement thereon, which criticisms would be referred to the board, there is no question but what the board would have been able to make many more suggestions.

The inventors who sought to invent devices for the Navy and submitted ideas to the Naval Consulting Board did not have the facts in regard to naval problems, they did not have the knowledge of the development of the arts concerned, and they largely drew on inaccurate descriptions of naval devices set forth in the public prints. Their devices were more or less a reflection of what they read in the newspapers.

Many of these men who came to the Naval Consulting Board, when they sat down and talked with the examiners, who explained the problem to them which they were seeking to solve, would, after the explanation laugh and walk out, being entirely convinced themselves of the futility of their idea.

Of course, it is possible that a man may invent something that on theoretical grounds would be turned down by an examing board, and this would be ncessarily so until the man could make a working model of his invention and demonstrate his idea.

The examiners were obliged to assume the truth of certain known laws, such as gravity, etc., and if a man came in and said "I have a little thing in my pocket that would overcome gravity," they would necessarily be very skeptical. He would have to demonstrate it by going into the air a certain distance and stay there. And so it was with a majority of the ideas and suggestions submitted to the board. They were passed upon, applying the well-known physical, chemical, mechanical, and electrical laws, and turned down if they were not in harmony with them. But always with the opportunity for the inventor to demonstrate that he had overcome these laws.

Many perpetual motion cranks sent in ideas to the board, and those men were asked to present a *working* model. It goes without saying that none of them did present a working model, but they were always convinced that just some little thing kept their device from being a success. For instance, the board sent a man 90 miles to investigate a counterweight flywheel. The inventor claimed a 15 per cent saving of energy; when he gave it a slight push it made almost a complete revolution, within, say, 5 degrees of completion, and all he wanted some one else to do was to put it over the 5 degrees. He was sent a letter asking for a *working* model, and he said he did not submit working models.

One method of placing sources of information at the disposal of would-be inventors so that their inventions would be built on accurate knowledge would be to maintain in every large industrial community an information bureau for inventors. The bureau should be in charge of a technically trained man, thoroughly familiar with all publications of a technical character, as well as with the shop and laboratory facilities of the locality in which the bureau of information is situated. He should also be familiar with the names of specialists in the scientific world capable of supplying the inventor with high-grade information on points that he is puzzled about. The bureau should preferably be near a good library to which the inventor could be directed by the man in charge of the bureau, and put in touch with books and papers dealing with the art in which he is working. In this manner he would learn what others had done in the same art.

Arrangements should be made so that this information could be imparted to the inventor without obliging him to disclose his invention to the man in charge of the information bureau.

The following is a summary of the functions which the bureau should perform, and the facilities which it should have. It should—

(1) Acquaint inventors with everything which has been attempted

already along the same lines, because most of them are absolutely ignorant of all that has been attempted by others.

(2) Invoke the aid of the most competent persons in working out the details of worthy problems which the inventor himself might not be able to work out.

(3) Furnish to inventors the means for a practical realization of their inventions, as regards material, workmen, specialists, etc.

(4) Influence manufacturers and constructors to make a practical test of worthy inventions.

(5) Afford the inventor protection so that his idea may not be stolen and that he may retain an adequate interest in the returns from its commercial development.

There are a surprisingly large number of people in the country of an inventive turn of mind and if their capacity in the direction of invention could be efficiently utilized there would be a great gain to civilization. Under present conditions this energy is dissipated on objects unworthy of the ability of the inventors owing to lack of knowledge on their part of some of the most elementary things. At the same time that this energy is being wasted there are crying needs for its application to the solution of certain problems.

There should not be any great difficulty in having the inventive problems confronting the Army, Navy, and civilian industries of the country formulated and placed in the hands of these bureaus of information. Under such a plan it would not be long before the bureau, by keeping its information up to date, would be a storehouse of information for inventors. Workshops for the making of models should be made available, and manual-training schools might render some assistance in this direction.

Such a bureau would no doubt find its greatest field for usefulness in coordinating and helping men well grounded in scientific and technical subjects and also men who work with their hands in the large industrial concerns of the country. In the laboratories and universities and scientific schools many men each year write theses upon various subjects in order to get their degrees and their writing involves a great deal of painstaking work. If such a bureau should bring to the attention of the professors and instructors in the schools certain problems which those in the active conduct of the industries were concerned with, many students could be put upon the work of solving it.

In the case of the men who work with their hands, as above described, their approach to the subject of creation of inventions would be along different lines, for they would, in the working with the machines and appliances with which they were familiar, see the opportunities for improvement and also have the opportunity of suggesting solutions of difficulties involving the use of devices with which they are working. If they were encouraged and helped by such a bureau they would be very much more inclined to attempt the development of their ideas.

The value of the bureau to those without either of the above qualifications would no doubt be more or less of a negative character, in that it would prevent would-be inventors from expending uselessly their energies on devices in an art which is very much developed beyond the point which they are seeking to improve.

It will be recalled that the results of the work of the Naval Consulting Board and the War Committee of Technical Societies indicated that the sending out of bulletins on the submarine and on aircraft problems, resulted in decreasing the number of poor inventions and it slightly raised the standards of those which were received.

During the war the Army and Navy widely used methods of communication between departments of the service and as well as civilian institutions which were found very useful, and which made short cuts between the various departments. If one department communicated with another, officially, it was necessary to do so by bringing it to the attention of the head of the department. But by the detailing of liaison officers to various departments and civilian organizations, an unofficial means of communication was established which enabled each department to keep in close touch with the other departments, and supply information and data so that there would be harmony in their relationship.

What is needed by inventors, manufacturers, and scientists, is a method of liaison by which the inventor and scientist can be kept in close touch with the inventive problems of commercial organizations. Many of the larger ones now maintain research and development departments which are a successful adjunct to the business. But there should be established by the Government or some other agency such an organization as outlined above to do this same work for the country at large.

Such bureau, if properly established and directed by men having initiative, imagination, and driving force, would be of untold benefit to the country as a whole.

In making a survey of the methods involved in handling of inventions from the public, one is impressed by the fact that all who undertook this work soon got into a negative frame of mind in regard to inventions. This frame of mind does not seem to pertain simply to Navy and Army officers, but even to civilians who were obliged to examine day after day a multitude of ideas and suggestions from the public. It is difficult to determine whether this is brought about by the fact that the average human being is a conservative person with a desire not to be too much disturbed by radical improvements, or whether it is due to the fact that on account of the low grade of the average material received one gets pessimistic and finally feels that there is very little virtue in inventions that come through the mail or are presented in person.

One is almost led to believe that the method of organization for the examination of inventions should be very carefully considered before adoption, and that there should be incorporated in such an organization departments whose sole duty would be to grade inventions without passing upon their applicability, so that the first grade material would be handled by men who had retained an optimistic expectation of finding something of value, and would not have their mind affected by the examination of a great mass of worthless material.

There should also be taken into consideration the fact that if the examiners are loaded with work and they are not in a position to let their imagination dwell upon a suggestion, very little is likely to be developed. Frequently if an examiner had nothing else to do except to consider a suggestion sent in by an inventor, he could, if he were of an imaginative turn of mind, allow his imagination to work and follow the idea into all its absurdities and ramifications with a possibility of hitting upon something which would be an outgrowth of the idea and which would be of value and on which money might be spent to advantage.

If, however, the examiner's time is fully occupied, he is likely to judge of the idea simply on the facts presented and without the addition of any imaginative contributions on his own part.

The conditions under which most inventions are usually examined are those where examiners have plenty of ideas as to where money might be spent to the best advantage in regard to the development of devices for improving the war equipment of the Navy, but feel that with the pressing duties surrounding them they can not devote the necessary energy to develop them. Therefore, when an idea comes in to build something, unless on its face it is of a wonderfully novel character, it would be relegated to a position secondary to the other ideas on their lists for development.

In its essence the introduction of inventions and their development is a selling proposition in that the people who are ultimately to become interested must become thoroughly convinced of the value of the idea and enthused in regard to its adoption. An idea therefore poorly presented, even if a good one, could not be "sold," to use a slang expression. Even if an idea is "sold" to a Navy officer who believes in it, and he gets to the point of giving time and knowledge to further its development, he is obliged, after its development, to "sell" the developed device to the department of the Navy that could use it, and this involves showing it to high officers and giving demonstrations of its usefulness in an adequate manner.

The path of an inventor in his introduction of an invention to any department of the Navy or Army, and in fact as well as to civilian manufacturers if it be a civilian device, is a long and arduous one. If he is a poor man he is obliged to first sell his idea to some one who will put up capital for the making of experiments and small-sized models. Then he must get additional capital to make working models and tests, each working model and test involving usually the incorporation of change. After the working model is made he must sell his idea to some officer in the Navy and convince him of its usefulness and efficiency, and finally that officer of the Navy must sell the idea to other officers who are concerned with the incorporation of it on shipboard.

It is therefore an obstacle race, and the first jumps over which the inventor is obliged to go are likely to eliminate him from the contest. As pointed out in this book, the ideas submitted to the Naval Consulting Board were in a large portion of the cases simply ideas on which no money had been spent for tests or models.

The inventor should no longer be neglected, misdirected, and exploited, but should be encouraged, directed, and supported in his efforts to improve the appliances that make for human welfare and happiness.

This is especially so now that the productive capacity of the world has been so much reduced on account of the World War. Every statesman who discusses the problem states that the destruction of property and the reduction in production during the war have resulted in a great shortage in necessities which must be made up.

Increase of productive capacity of the human race has been largely brought about through invention, yet strangely the production of inventions has never been organized. Inventions have been largely developed by uncoordinated individualistic effort. From now on the inventive ability of peoples must be organized, coordinated, and fostered by centralized agencies in order to increase the productivity of man.

One invention frequently does the work of hundreds of men, and if attention is given to increasing the number of labor-saving devices increase in production automatically takes place.

The broad question as to how to best utilize the inventive and scientific resources of the country for the Navy in case of war is a most interesting one, and predicated upon the experience of the Naval Consulting Board the following suggestions if not already in use are offered by the author.

In the first place there should be a body of men whose entire time and attention should be devoted to the problem of improving the equipment and devices in use by the Navy Department. This responsibility should be definite and fixed, and adequate authority should be coupled with it. If the equipment of the Navy is not improved as rapidly as it should be, then there would be some one upon whom the responsibility for such a condition could be fixed.

The responsibility having once been vested in such a person or body, it should be incumbent upon the one having the responsibility to thoroughly inspect at stated intervals the inventions and devices on all ships and floating equipment and at navy yards, testing stations, laboratories, etc. Reports having been made by the inspectors, it should then be the duty of this person to point out wherein our equipment could be improved, and he should take steps to improve it. Scientific research should be undertaken when circumstances indicated it as necessary.

There should be established a close connection between this department, the inventors. engineers, and scientists throughout the country in order to focus their attention on certain problems.

If this person or body vested with the responsibility of improving equipment were made up of naval officers, they should be encourged and directed to become members of scientific societies, and keep in close touch with scientific progress.

As the devices used on shipboard usually originate on land, and the arts on which they are founded usually make more rapid progress on land than those on sea have any idea or conception, some of the inspectors should be men thoroughly familiar with the arts in use on land. This body of critics should also arrange to get the cooperation of all line officers and men for the improvement of equipment and should arrange for a suggestion box or other instrumentality on ships and in navy yards, into which officers and men of the service could drop suggestions for the improvement of the equipment which they were daily operating. These ideas and suggestions should then be handled in such a way that those who pass on them would not know from what source they came and who was the originator of them. This might be done by giving a number to each communication, making a copy of the suggestion with simply a number, and then submitting the suggestion to certain persons who were charged with the duty of finding suggestions for new devises and who were not charged with the duty of trying to dispose of suggestions in order to get them out of the way. The examiners of these devices should not know whether the suggestion came from the commanding officer of a ship or from a sailor. The recipient of the idea should be put on his mettle to use his utmost skill in the working out of the idea, and he should be in such contact with the scientists and inventors of the country that he could call on any of them at any time for expert assistance and advice.

The work should have liberal appropriation from Congress. In connection with this direct drive to give the Navy the best inventions possible, it might be desirable to formulate certain general problems for the improvement of the equipment in the naval service, of such a nature that they could be distributed to the engineering and technical societies, in order that those members of the societies with a taste for invention and research, might have an opportunity to work on them. Such problems could also be distributed through other agencies.

This organization, charged with the duty of improving the equipment, should have at its disposal adequate funds and laboratory facilities for working upon and developing the ideas of importance, and should have requisite power to organize the work from the top down, without interference, and held responsible for results.

The members of the board metaphorically took off their coats and did work which, under a properly organized board, should have been done by salaried employees who could devote their entire time and attention to it. It was very much as if the individual members of a board of trustees of a university were to do the work of the president of the university, and the secretary of the university, as well as the work of the instructors and professors. By this analogy Mr. W. L. Saunders could be likened to the trustee who acted as president of the university, and Mr. Thomas Robins as secretary and treasurer. Both of these men were heads of large industrial enterprises, Mr. Saunders being president of the Ingersoll-Rand Co. and Mr. Robins of the Robins Conveying Belt Co., and they both devoted an immense amount of time to the work of the board.

Other members of the board did work along the lines of experimentation and research which might be likened, in carrying out the figure of the university to trustees doing the professorial work of the university.

As those organizations are most effective which have specialization and differentiation of functions, so the Naval Consulting Board should have had this same specialization and differentiation so that the board could act as a board of advisors to others who would actually do the work on a salaried basis.

The Naval Consulting Board, organized without authority or responsibility, could do very little but suggest; it had no power to organize this work as it should have been organized and no power within itself to carry out the improvements of naval equipment. The responsibility for the improvement of naval equipment and adoption of inventions by the Navy Department was vested in the Naval Establishment itself. This was properly so under the circumstances.

It would not have been advisable for the Secretary of the Navy to give too much power to the Naval Consulting Board before knowing who the individual members of the board would be, as well as their reaction to their new environment, which consisted of a rigidly organized Naval Establishment in which the duties of the officers and men were prescribed with great detail, and a civilian public interested in inventions, engineering, and scientific matters generally.

The Navy Department, through long custom and usage, had developed certain methods for the adoption of new devices which made for conservatism, some of them due to the peculiar limitations imposed upon all inventions to be used on shipboard where space is limited, and where sea conditions might render successful land inventions inadaptable.

Up to the time that the board had had its experience with the public, which has been pointed out in this book, no one knew just where the valuable inventive talent of the country was located or how best it could be mobilized.

The Naval Consulting Board was composed of brilliant men of strong individuality, successful in their own undertakings and carrying heavy business responsibilities. Most of them had become executives of corporations employing large numbers of men, but they patriotically gave an immense amount of time to the work of the board. Had the Secretary of the Navy, at the time that the board was formed, known that the engineering societies would have selected for service on the board men of the character and ability of those chosen, and if he had also known that the general public, unacquainted with highly technical and scientific matters which are concerned in the improvement of naval equipment, would not produce anything of great value, it is the author's opinion that he would have been justified in giving the Naval Consulting Board more definite authority and responsibility.

This would have made it possible for the board to create a staff of salaried employees of high scientific attainments, with command of adequate laboratory and shop equipment, so that the development and improvement of naval equipment could be handled by men who made it their sole duty. The executives could then initiate methods for fostering and developing the best ideas from men throughout the service for the improvement of equipment and also work up the best of the ideas from civilian inventors, scientists, and engineers. It could also have been arranged for the civilian talent to work upon the solution of naval problems.

The Naval Consulting Board would then act as the board of advisers to such salaried officers and employees very much as the board of directors of a business corporation acts in regard to the president and other executives in such an organization.

Under the scheme proposed, the persons holding executive positions would devote their entire time and attention to the improvement of naval equipment, and they would be in a position, with the support of the Naval Consulting Board, to make themselves very effective.

Although by methods of organization a great deal can be accomplished to stimulate scientific research and invention, yet in its last analysis the whole question is one of creating a human organization, built up around leaders in each scientific and inventive field. Each of these men should be the rallying point for gathering together men who desired to be the disciples of this great scientist. They should respect his leadership to such an extent that, as captain, they would follow him into the unchartered lands of knowledge.

Men interested in certain subjects always seek the master of that subject. The little group of men around the master would devote their whole time and attention to the cultivation of the master's field. As a result, the extension of knowledge in this field would react on all other fields, and out of this reaction would grow scientific progress and invention.

However perfect an organization might be, if it should lack this human contact, mediocre results would likely be obtained, as scientific research is essentially human and an organic phenomena rather than an inorganic phenomena. The creation of inorganic rules and regulations and red tape for the development of scientific research would avail nothing if the organic matter were not also incorporated in the scheme so that there would be the warmth of personal contact and stimulation of one mind by another.

CHAPTER IX.

MERITORIOUS INVENTIONS FROM THE PUBLIC.

Although but one device received by the board from the public was put into production, yet there were several others which might have been used had the exigencies of the war demanded them. These inventions were separate and distinct from any that were made by the members of the Naval Consulting Board themselves, which are described in another place in this book.

In this chapter is given a short description of the history of those devices which were received from the public by the board and which were considered to be of merit.

First of these is the Ruggles orientator, which was used by the Navy Department before the signing of the armistice.

On January 19, 1918, Mr. W. Guy Ruggles presented to the Naval Consulting Board a device for the training of aviators in the sense of equilibration. This matter having been brought to the attention of the board through its secretary, Mr. Thomas Robins, he was appointed a committee of one, with power to act and develop the device.

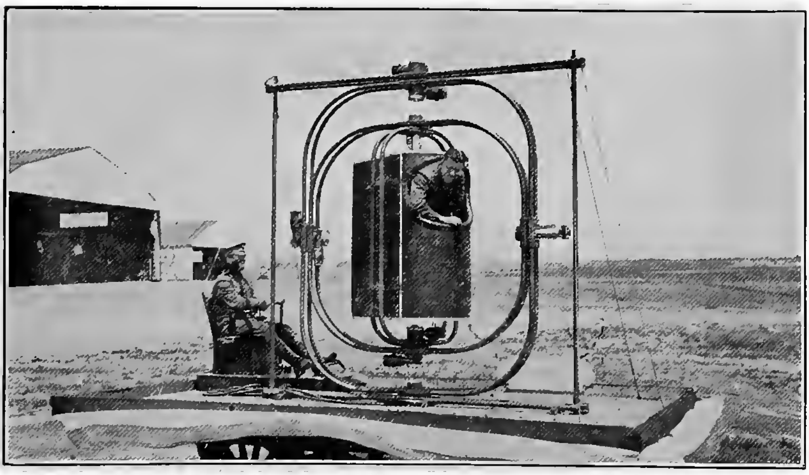
Before presenting his idea to the Naval Consulting Board, Mr. Ruggles had presented his idea to many others, but was unable to convince them of the desirability of making the experiments which he recommended, probably owing to the very intricate and involved nature of the problem which he sought to solve.

The device of Mr. Ruggles was based on the following theory:

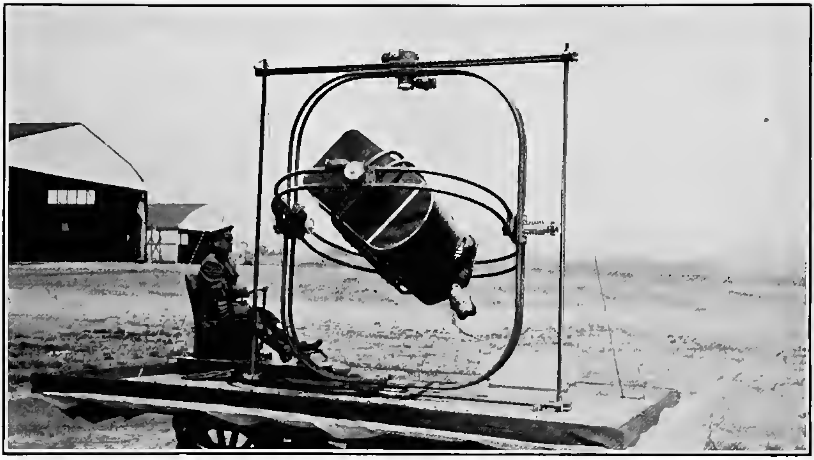
From the time the aeroplane leaves the earth until it returns to the earth it is sustained by a mobile medium and is capable of motion in every conceivable direction. Therefore the piloting of an aeroplane involves a problem in physiology somewhat different from the customary activities of man while on earth.

Just what the man in a falling, spinning aeroplane might be called upon to do in his efforts to recover a normal flying position became more intricate as the problem was studied. Mr. Ruggles became convinced that the semicircular canal system of the inner ear, generally referred to as the static labyrinth, played a very important part in functioning those muscles which a pilot uses in guiding his aeroplane.

RUGGLES ORIENTATOR. NORMAL FLYING.



RUGGLES ORIENTATOR. SIMULATING NOSE DIVE.



RUGGLES ORIENTATOR. SIMULATING TAILSPIN.

This was substantiated by careful perusal of the work and experiments of famous otologists.

These scientists, by most delicate surgical operations, established the fact that an animal whose semicircular canals had been removed was unable to direct its movements intelligently; and, furthermore, that while animals so operated upon might in time learn to direct their movements intelligently on the ground, they could not while in space.

For instance, the pigeon so operated on learned to walk, but could not fly; a dog so operated on was unable to jump from a height and land on his feet squarely; a man who has by accident or disease lost the labyrinth suffers terrible vertigo and never recovers his certainty and delicacy of muscular movement.

It is perfectly apparent that the labyrinth and its associated faculties and muscular reactions is capable of extensive development. Spinning dancers and skaters, by practice, rotate with considerable velocity without noticeable dizziness, and trained acrobats perform feats of equilibrium totally impossible in the early stages of their training.

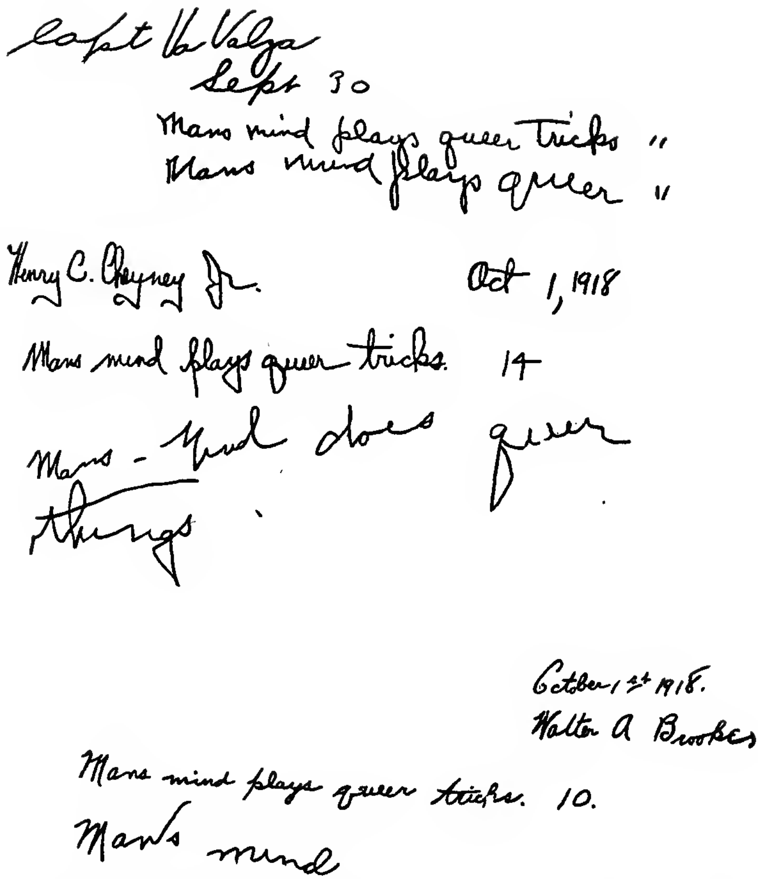
He believed that if means were available, the student aviator might so develop his faculties of equilibration and muscular control that the piloting of an aeroplane might be mastered with a minimum of danger. The static labyrinth being an entirely involuntary organ, operating through the involuntary system when under the excitation of unaccustomed spinning motions and unusual positions, until more completely developed and trained, causes involuntary muscular actions entirely beyond the control of the student aviator. A means that might contribute to the development of this faculty in student aviators seemed desirable.

It obviously must consist of a seat for the student aviator resembling as closely as possible the seat of an aeroplane, and the control members used to guide the aeroplane properly placed in relation to the seat. This apparatus should then be so mounted that it might have free rotational possibilities in three planes of direction simultaneously, and in addition to this should possess the possibility of a falling motion in the vertical plane. He did not think it desirable to incorporate the progressive motion on account of the fact that human faculties do not sense a uniform progressive motion. The falling motion, however, was of vital importance, for the labyrinth contains as a part of its mechanism six small otoliths, which sense the acceleration in the beginning of each falling motion and are responsible for the most violent muscular reactions of the involuntary system.

His plan was to design an amplified gimbal construction apparatus which would consist primarily of a rectangular frame in which rotated a tubular steel ring about 9 feet in diameter, which rotated about a vertical axis. Within this a smaller ring was to be mounted for rotation about a horizontal axis, and within this a still smaller ring was to be mounted for rotation about an axis at right angles to either of the others, and within this third ring was to be mounted a section of the fuselage of an aeroplane for the student aviator, consisting of a seat and control members of an aeroplane. The apparatus was to be controlled electrically, the current being introduced by means of a series of rings and sliding contacts mounted on one journal of the axis of each of the rings, and an electrical motor and suitable gear reduction mounted on the opposite axis of each ring. The electric current first led to the seat for the person on the innermost ring, and from there it was to be distributed to switches directly connected to each of the control members (the joy stick and foot bar), and from these switches through rheostats to the motors on the various axes of the apparatus.

By this arrangement it was to be made possible by the movement of the foot bar and the joy stick to close the switches which would operate the motors, so that the student aviator would be given a turning motion in any of the three planes of direction. Pressure with the left foot on the foot bar closed the switch operating the motor on the vertical axis, causing the student aviator to turn to the left as in an aeroplane. Neutralizing the foot bar would stop the motor, and pressure on the right foot would reverse the motor, causing the apparatus to turn in the opposite direction. The moving of the joy stick forward caused the motor on the horizontal axis to dip the seat forward; throwing the joy stick backward would cause the seat to turn backward by operating a motor on the horizontal axis corresponding to the action of an elevator in the flying aeroplane. Movement of the joy stick to the right or left would cause the seat to revolve to the right or left, as the aileron of the aeroplane. The speed of each of these motors was to be controlled through a rheostat which was gradually cut out by the advance of any of the controls. The speed of rotation was therefore to be regulated to suit the wishes of the occupant.

Rotational possibilities were made to include a maximum speed of 30 turns a minute. While this would be faster than the rotational possibilities of an aeroplane in ordinary maneuvers, it had been proved that the static labyrinth of the ear of the aviator becomes accustomed to a rapid turning movement and is never affected by a movement slower than the one it has become accustomed to. By means of the rheostat, the speed could be reduced to a very few turns a minute, thus providing a possibility of greatly increased speed as the training of the student aviator progressed.



HANDWRITING OF STUDENT AVIATORS IN DIFFERENT POSITIONS WHEN BEING TRAINED IN A RUGGLES ORIENTATOR.

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A control station was also established outside the apparatus consisting of a series of switches and rheostats by means of which the instructor outside the apparatus might take the control away from the man inside and operate any or all of the motors to rotate the student aviator as desired.

The apparatus was to be designed to rotate the student aviator in any plane of direction, and give him some of the falling sensations which he would be required to assimilate in flying in an aeroplane. It also made possible the careful study of the peculiar muscular reaction attending the unusual positions in which a student aviator finds himself while in this machine, or in an aeroplane.

The Naval Consulting Board proceeded immediately to have a machine constructed, and following is the way that the machine impressed an accomplished observer:

> * * * It has a joy stick, which works exactly like the one in a plane—direction by the feet, so all the controls simulate the aeroplane. You are strapped in the seat, which is cardan mounted, that is, a ring within a ring within a ring, an electric motor driving each axis mounted on the next ring outside, the last one being mounted on stationary supports and driving an orientating member about a vertical axis. These motors are driven from a little controller outside, which acts through a relay to take the control away from the man inside and hand the control back to him whenever the stationary operator desires.
>
> With this machine you can perform all of the functions of the aeroplane so far as angles and angular velocity are concerned, and its primary object, I should think, is to train the mind so that it can discern and separate real phenomena from hallucinations created by the continued action of the little cuneiform located near each ear.

The length of time taken to develop the Ruggles device may be taken as an indication of the length of time that is required to develop devices in war time. It was brought to the attention of the board on January 19, 1918, and the necessary appropriations were then made to construct it. Arrangements had to be made with a machine shop and workmen to complete a machine already partly finished. It was not ready for inspection before July, 1918, a period of some six months; so that if an inventor is given a reasonable time to develop the device before he presents it to the Government, of, say, six months, and it takes six months under conditions prevailing during the war to get out a full-sized working model, it can be readily understood why so many devices were just about ready to be used at the time of the armistice, which occurred on November 11, 1918, war having been declared April 6, 1917.

The claims which Mr. Ruggles made in regard to the advantage that could be gained from training aviators on the ground before they took their first flight seemed to be borne out by tests on student aviators at the Massachusetts Institute of Technology, in Boston, Mass. Naval observers who had observed the flying records of men who had been trained in the Ruggles orientator came to the conclusion that the data furnished by their training course in that machine were a fair index of what their ability as fliers would be. It seemed to show that men who operated the orientator successfully were more likely to become aces in aviation than men who did not do so.

The Army also became interested in the device, and it placed orders for 15 of them, for use in training Army aviators at the time of the armistice.

In March, 1917, Dr. Miller Reese Hutchison made rather complete tests of a bomb dropping device which was to be dropped from aeroplanes upon enemy submarines. It consisted of a network of wire with bombs distributed throughout the network, so this net would wrap about objects on which it fell in much the same way as a cast net would wrap around a school of fish. The tests of this device were rather elaborate and were conducted off Sandy Hook, where an aeroplane dropped these bombs on a target which had been provided.

Changes in submarine warfare, through which submarines went farther out to sea and beyond the range of aeroplanes operating from the shore, together with other considerations, including the question of the safety of the aviator flying with bombs suspended in this manner, prevented this device from being adopted.

Dr. Hutchison conducted a series of tests on a rapid-firing infantry rifle. The gun was recommended by the Naval Consulting Board for the consideration of the Ordnance Department, United States Army.

It had been assumed that it was impracticable to tow nets or plates alongside of a ship to protect it from torpedo attack. One of the objections being the difficulty of towing them vertically. In the autumn of 1917, however, S. Davis Robins presented a device to the Naval Consulting Board which gave such promise of success that the board decided that exhaustive tests to check the opinion of the experts above mentioned should be made. Mr. Robins's device consisted of:

The function of this screen or plate was to detonate the torpedo at a safe distance, from the hull of the vessel. It was so designed that it had no tendency to depart from the normal vertical position in the water, although it was not braced and was free to yield to the thrust of waves and the motion of the ship. The flexibility of this device and its construction of smooth steel plates caused it to create the minimum of friction, while its construction required the minimum quantity and weight of material. In a heavy sea or when the vessel was not in the danger zone the screen was designed to be housed against the side of the vessel. The flexibility and vertical position of the plate were maintained by placing the point of support on the forward end of each plate so that it would be slightly lower than the aft one, the result being that the plate was hinged upon a slanting axis. Any movement of the plate from a normal position was met by an increased resistance of the water. To avoid this resistance the plate therefore retained its vertical position. Each plate was supported by two booms, which were hinged against the side of the vessel above the water line. Lifts running from the ship's rail to the outer end of the booms supported them when lowered. A guy running diagonally forward from the after end of the plate was used to relieve the longitudinal stress caused by the movement of the vessel. To house a plate a few turns were taken with a line around a revolving shaft which was inside of the rail and operated by a donkey engine.

On a ship 425 feet long, 60 feet beam, and 15 feet draft there would be nine plates 20 feet long, 90 feet forward end and 15 feet at the aft end. These plates were carried by booms which extended out from the ship, there being a boom for each plate. The aft end of the plate was supported directly from this boom. The forward end of the plate was supported from a bridle which attached to the side of the ship through a sheave. The forward end of the plate was towed by a line from the boom next ahead, which was also used to support the rear end of the preceding plate.

The committee which was appointed by the Naval Consulting Board to test this plate reported that it had been demonstrated in experiments with one full-sized plate that it maintained its vertical plane by the stability imparted by the method of suspension and towing and that the only experiment still to be tried was its operation in weather at sea not rougher than would permit the operation of a submarine. The committee reported that the speed of a vessel towing sufficient plates to protect it would not be reduced over 1 knot per hour on a vessel having a speed of 10 knots. The committee reported that further sums should be expended for full-scale experiments. These experiments were, however, not carried out at the time of the armistice.

Among the inventions submitted by Mr. Hudson Maxim, chairman of the Committee on Ordnance and Explosives, which were found to possess the greatest promise, were the following:

An invention for making gun tubes with great hydraulic pressure. Before final machining of gun and rifling, the metal was stretched by hydraulic pressure so that all layers of the cylinder would be equally stressed in firing. This permitted of gun manufacture in one piece with decreased thickness of wall for equal sizes.

Owing to the strenuous activities of the Naval Consulting Board in combating U-boats, especially in the North Sea, the Bureau of

Ordnance deemed it wise to take no active measures in the development of this invention during the maximum stress of the war.

It is interesting to note here that after the United States entered the war it was learned that the French had for some time been employing a method essentially the same as the Emery method for forging their large field guns.

An invention for mounting large guns on railroad cars and securing the cars in concrete emplacements, forming a mobile, rigid and effectual gun mount for immediate action, together with means for detaching the car mount carrying the gun and running it by rail to any other emplacement, the same being mainly intended for coast defense. The United States Army has, during the past two years, been devoting considerable attention to mounting guns in essentially this manner.

Amorphous graphite in an exceedingly fine state of division, called colloidal graphite, was submitted to the Committee on Ordnance and Explosives as a lubricant for gun barrels to lessen friction and minimize erosion. Experiments with 6-inch guns had been made in England with this form of graphite, and it was found that when a gun was swabbed with aquadag the range was materially increased, but it was necessary to use a charge of quicker powder. Mr. Maxim recommended that the Navy Department conduct the necessary experiments with this form of graphite.

An illuminating flare was brought to Mr. Maxim's attention, and experiments were made with it at Maxim Park, with marked success. He brought this invention to the attention of the Committee on Ordnance and Explosives, but the matter was referred to the Bureau of Ordnance of the Navy Department, and Mr. Maxim was delegated to take it up with the bureau, which he did.

Mr. Maxim was informed that the Navy Department had ordered large numbers of the flares.

A sea sled was brought to the attention of Mr. Maxim by its inventor. The sea sled is a craft of very peculiar construction. It draws but very little water indeed, in fact, it skims over the surface of the water, the water passing under it in such wise that the boat is held rigidly to its course against rolling, and is capable of making comparatively short turns at high speed. The craft makes a remarkably stable platform and would be excellent for a depth-bomb gun platform for throwing depth bombs at submarines.

The inventor offered to build a boat capable of traveling from 40 to 50 miles an hour, and capable of carrying one full-sized 21-inch torpedo, or an equivalent weight in depth bombs. Reports on the trial of the sea sled seemed to bear out the claims of the inventor that it was a good rough-water boat, and could keep the open sea at high speed.

A machine-gun mount, which was adapted particularly to trench warfare, and could be raised and lowered with great facility, sighted, trained, and fired by the gunner from a position of comparative safety, considerably below the gun, was submitted to the Committee on Ordnance and Explosives by the inventor.

The mount functioned well in all positions, giving practically universal movement to the gun. On account of the numerous points of adjustment necessitating loose joints there developed quite a little vibration or "whipping" of the gun during firing. Whether or not this was more or less than the vibration of the gun when mounted on the usual tripod could not be determined as there was no means of comparison. A clamping device for each adjustment is used for taking up lost motion, but these should be made more accessible to the operator.

The mount is unnecessarily complicated and heavy, but this objection could be overcome by introducing better mechanical design of some of the parts. The periscope and extended trigger functioned properly and would be of advantage when gun is used in exposed position.

It may be said that the mount accomplishes the purpose for which designed, that is, rendering possible universal training of the gun without moving the tripod of the mount and with an increase of safety to the gunner, but before quantity production could be considered, a redesigning of the essential features would be necessary.

Two inventions by independent inventors relating to means for accurately determining the position of a hidden big gun by the difference in the arrival of the sound of its report at distance stations, were also looked upon favorably by Mr. Maxim.

Mr. Maxim, chief of the Committee on Ordnance and Explosives of the Naval Consulting Board, also investigated noncorrosive alloy with antifriction characteristics as well as toughness, which made them important as bearing metals, and came to the conclusion that this alloy had important characteristics distinguishing it from others of the same class, which made it of considerable value for certain purposes.

CHAPTER X.

BRANCH OFFICES.

SAN FRANCISCO OFFICE.

In the early part of the board's activities a number of inventions were forwarded from the Pacific slope and the board needed some one to investigate them who was living there. As a result, Mr. A. H. Babcock, a well-known engineer of San Francisco, was selected. The investigations increased rapidly in number, and it became desirable to establish a branch office of the Naval Consulting Board in San Francisco, and he was placed in charge of that office.

He rendered a great deal of service to inventors on the Pacific coast and saved them an immense amount of energy and time by consulting with them in regard to their devices before they had expended large sums of money in developing them without adequate information in regard to their applicability and feasibility.

Inventors on the Pacific slope in certain cases made trips of some 1,500 miles to the San Francisco office in order to submit inventions, and if that office had not been established they would no doubt have taken much longer trips in order to present them to the authorities in Washington and New York.

The following correspondence passed between the Secretary of the Navy and Mr. A. H. Babcock:

AUGUST 5, 1918.

MY DEAR MR. BABCOCK: The Naval Consulting Board have nominated you as the associated member to act as the representative of the board in San Francisco and on the Pacific coast in the work of examining and investigating inventions, ideas, and devices for the benefit of the Government.

It will give me pleasure to receive your acceptance of this appointment.

Very sincerely, yours,

JOSEPHUS DANIELS,
Secretary of the Navy.

Mr. A. H. BABCOCK,
65 Market Street, San Francisco, Calif.

AUGUST 19, 1918.

From: Western representative, Naval Consulting Board.
To: Secretary of the Navy.
Subject: Appointment.

I have the honor to acknowledge receipt of your favor of August 5, 1918, and to accept the appointment.

To contribute my services, particularly at this time, in this or in any other capacity, is both a duty and a pleasure.

Very respectfully,

ALLEN H. BABCOCK.

CHICAGO OFFICE.

On or about June 4, 1917, a Chicago office of the Naval Consulting Board was opened. Mr. Frederick K. Copeland and Lieut. Col. Bion J. Arnold, a member of the Naval Consulting Board, were put in charge of the office, which was located at 122 West Adams Street, and which was moved on February 25, 1918, to 72 Adams Street.

The committee that looked after inventions in Chicago consisted of: Frederick K. Copeland, Lieut. Col. Bion J. Arnold, William Hoskins, Robert W. Hunt, and Peter Junkersfeld.

The organization of this office was brought about by order of the Secretary of the Navy, and Rear Admiral William Strother Smith, the liaison officer of the Naval Consulting Board, made a trip to Chicago to get the office started.

This office handled some 2,456 inventions, and rendered the same service to the district around Chicago that the San Francisco office rendered to the inventors on the Pacific coast.

WASHINGTON OFFICE.

It became apparent that owing to the numerous conferences that were necessary between the members of the Naval Consulting Board, Army and Navy officers, Patent Office, and Government engineers in Washington, it was desirable to open and maintain a branch office in Washington, D. C. On April 25, 1918, the branch office was opened at 718 Seventeenth Street, and Mr. D. W. Brunton became the member in charge of the joint offices of the Naval Consulting Board and the War Committee of Technical Societies. Both the Naval Consulting Board and the War Committee continued, however, to maintain their main offices at 13 Park Row, New York City, the War Committee office being in charge of E. B. Kirby, vice chairman.

Between April 26, 1918, when the branch office was first established in Washington, and about September 1, 1918, at which time the new Navy Building was completed at Eighteenth and B Streets, experience was gained as to the value of having a central office in Washington. As a result, in order to bring about a close relationship between the various bureaus of the Navy Department, the departments of the Army, Government officials and bureaus, it was decided to move the main office of the Naval Consulting Board from 13 Park Row, New York City, to the new Navy Building, Washington, D. C., and this was done about September 12, 1918.

These arrangements brought about a consolidation of all work on inventions received from the public. This new arrangement was in operation for about two months before the armistice and the arrangement was successful, as it gave the examiners of inventions and those in charge of the direction of the work of the board greater facilities for quickly getting in touch with various bureaus of the Army and Navy Departments and Government officials.

After the establishment of the Washington office and before making that office the main office of the Naval Consulting Board, cordial relations had been established with the Inventions Section, General Staff of the Army, and Mr. D. W. Brunton, the member in charge of the Naval Consulting Board's work in Washington, was made on May 10, 1918, a member of the Advisory Board, Inventions Section, General Staff, by order of Gen. Peyton C. March. As the Inventions Section had just recently been organized, Mr. Brunton was able to give that body a great deal of information in regard to the experience of the Naval Consulting Board in handling inventions from the public, and rendered to them a needed service. Thereafter cooperative and cordial relations were maintained between the two organizations, and inventions for Army use were sent to the Inventions Section of the General Staff by the Naval Consulting Board and vice versa.

Mr. Brunton also acted as chairman of the Engineering Council's War Committee of Technical Societies and was a member of the National Research Council. As a result, he was able to bring about relationships with all these organizations which made for their efficiency.

The facilities of the United States Bureau of Standards were also put at the disposal of the Naval Consulting Board, and as a result a network of relations was established at the close of the war which gave promise of increasing the value of the work of the board. As a result of this move, the files and records of inventions of the Naval Consulting Board were shipped to Washington, D. C., and are in the new Navy Building.

These changes in the handling of inventions were brought about through experience and the reaction of the board to the environment in which it found itself.

It was the logical thing to establish the first office of the board in New York City, as a large percentage of the members of the board resided in and about New York. But when the organization had developed into one in which there was a staff of paid technical examiners passing upon inventions, and submitting only certain ones which had merit to the committees of the Naval Consulting Board, the situation became one in which it was desirable for those doing the day-to-day work in connection with inventions to have access to all Government sources of information and a close touch with the different bureaus of the Army and Navy.

After the removal of the main office of the Naval Consulting Board to Washington, the force consisted of Mr. D. W. Brunton, member of the Naval Consulting Board, in charge of that office; Rear Admiral

William Strother Smith, representing the United States Navy, and in charge of the office of Secretary of Navy, inventions; civilian staff of examiners, assistants, stenographers, liaison officers, etc.

After this arrangement went into effect the meetings of the board were held in the offices of the board in the new Navy Building, which was convenient for all concerned. Prior to this time most of the meetings of the board were held at the Carnegie Institution of Washington, Dr. Robert S. Woodward having extended the hospitality of this institution for meetings of the board, of which he was a member.

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CHAPTER XI.

INVENTIVE ACCOMPLISHMENTS OF MEMBERS.

After having selected Mr. Thomas A. Edison to be president of the Naval Consulting Board, it will be recalled that Secretary Daniels cast the burden of selecting other members of the board upon the 11 largest engineering societies of the country. It necessarily followed that these societies would have varied ideas as to whom was best qualified to serve on such a board. As a result, there were selected several members who were particularly noted for their success in the business world and their executive and administrative ability.

Many were attached to large manufacturing and industrial corporations in an executive capacity, and the major part of the time was necessarily taken up with the task of administering the affairs of these corporations. They brought to the board, however, the support of their organizations and the ability to use the inventive talent of their entire organizations whenever that seemed desirable.

Some of the other members of the board were preeminently engineers with some accomplishments as inventors, but their principal ability was that of engineers. Several, however, were preeminently inventors and devoted their entire time to the creation of new devices, either individually or in cooperation with their respective organizations, they having achieved distinction and success through inventions which were being administered by the corporations of which they were the heads. They were, therefore, particularly well placed to work upon and develop war inventions.

Those members who were of the executive and administrative type devoted themselves to the use of these talents in behalf of the Naval Consulting Board in its relations with Government bureaus, departments, and in general in building up its contacts and fostering the work of the board by directing the inventive work of others, as well as the promotion of such activities of the board as the preparedness campaign and the fuel-oil conference.

Those members of the board who were of the inventive type created many inventions and also made contributions of an inventive character which tended to develop the arts to which they devoted themselves.

Mr. Thomas A. Edison, having been asked to become president of a board which was to be formed, did not know who his colleagues on the board were to be, as they were selected, as pointed out in the first chapter, by the various engineering societies of the United States. He is a man who is and was more interested in inventions and creating of devices than in organization, as pointed out in the chapter on "Organization," and it was understood between him and Secretary Daniels, when he took the presidency of the board, that it was his inventive talent and initiative that was desired rather than to make draft upon his time for administrative and executive duties.

In January, 1917, Mr. Edison was asked by Secretary Daniels to come to the aid of the country by devoting himself to the study and suggestion of such ideas and inventions as might seem to Mr. Edison to be useful if the United States should become involved in the war with the Central Powers.

Accordingly, Mr. Edison put his business affairs entirely in charge of his officials, gave up his other experimental work and investigations, and devoted himself exclusively to this work for the Government and remained so engaged for about two years.

At the beginning of this work Mr. Edison gathered around him, as assistants, such young engineers as were at the time in his employ. He also obtained some volunteers from various colleges and universities, and he prevailed upon some industrial concerns to assign a few of their technical men to come to the laboratory and help along in the work. Beside these, Mr. Edison had about 50 skilled mechanics in his laboratory workshops, on whom he could call for making experimental apparatus.

The ideas and devices were developed almost entirely by experiment, and those mentioned relate to naval equipment or operations and merely decribe the first experimental results, and are not intended to be the final word on the subjects and do not go into all details. They were for the purpose of giving the Army and Navy officials the results of Mr. Edison's experiments and were intended to stimulate them to further inquiry for details and to continue the experiments if desirable.

A great many other experiments on different subjects were carried on but were not brought to a stage where definite reports could be made—such experiments being laid aside for subjects which at the time were deemed of more immediate importance.

A descriptive list of devices worked on by Mr. Edison follows:

DETECTING SUBMARINE BY SOUND FROM MOVING VESSEL.

When submarine activity began to play havoc with shipping the problem of detecting the location of submarines by sound was considered one of the foremost problems of the day, and in a very short time it was recognized as being perhaps the most difficult one, as set forth in the chapter on "Special Problems."

Immediately on beginning his war work for the Government, Mr. Edison gave this problem a large part of his attention. He commenced with exhaustive experiments along the line of the induction balance, but after about two months of intensive work along this line he came to the conclusion that it was hopeless to find a solution in this type of device.

He therefore turned his attention to other means which seemed to him more promising. While conducting studies on the various lines indicated on the other pages hereto attached, he continued giving a great deal of personal attention to this problem all through the two years that he gave to the Government.

It is unnecessary to review in detail the vast number of experiments that he made in pursuing this line of inquiry. He passed through many stages of employing telephones, audions, towing devices, resonators, etc., and in the summer and fall of 1917 had reached a fair degree of success in detecting sounds of torpedoes as far as 5,000 yards distance.

These results were mostly obtained on board a vessel that was not moving, although in the case of the towing devices only fairly good results were had during the progress of the vessel. The noises caused by the wash of the waves against a towing device prevented the obtaining of as good results as in the other cases.

During the early months of these experiments submarine activity of the enemy had resulted in vast destruction of ships and Mr. Edison began to view the solution of the problem from a different angle. It became evident to his mind that if it were possible to circumvent the submarines and avoid the loss of ships, the result would be as satisfactory as if the submarines themselves were destroyed. He, therefore, decided that if he could provide merchant ships with a listening apparatus that would enable them to hear the sound of the torpedo as soon as it was fired from the submarine and also provide the merchant ships with a means of changing their course speedily to another course at right angles the torpedo would miss its mark and the merchant ship would proceed on its way. If another torpedo were launched, the same tactics could be again resorted to.

Mr. Edison, therefore, proceeded along this line from that time on. After a time he discarded towing devices for the reason above given, and he became convinced that if he could install on a ship a device that should be arranged so that it would always be from 10 to 20 feet ahead of the bow of the vessel, and if this device should carry a vibrating diaphragm it would not have to contend with the noises of the ship itself (as these could be compensated for and made inaudible) nor with the noise occasioned by the rippling of water along the sides of the vessel, nor water eddies affecting the acoustic apparatus. As the result of a long line of subsequent experiments he constructed such a device which was in the form of an outrigger suspended from the bowsprit by a special designed appliance. This attachment was one by which the arm and bowsprit were connected to a worm actuated by an electric motor, whereby the bowsprit and arm could be swung in a circle toward the boat and the entire device landed on the deck for making any necessary repairs. By this arrangement the listening device could be taken from and returned to position in the sea in a few minutes.

This device was afterwards given practical tests in very rough seas, fulfilling all requirements, and was not in any way damaged or put out of commission, even in the roughest kind of cross seas, with the vessel going at full speed, 14 knots per hour.

This listening device was about 20 feet in length by about 16 inches in width, and the body was made of brass, both fore and aft ends being tapered. It contained brass tubes with a phonograph diaphragm at the end which hung in the water. The listening apparatus was carried in a small room at the bow of the boat. No batteries were used. There was a compensator which could be connected with the main shaft by means of which the noise of the vessel's apparatus would be canceled out, and by an adjustment Mr. Edison could also cancel out other boats that made interfering noises.

With this device boats moving 1,700 yards away could be readily heard while the vessel was going full speed. A submarine bell 5½ miles away could also be heard by the operator while a big storm was in progress and the boat also proceeding at full speed, and this with only plain diaphragms.

With this device there would be no difficulty whatever in hearing a torpedo more than 4,000 yards away, and this is far beyond the effective distance at which a torpedo can be launched from a submarine. The noise by a torpedo is very piercing and peculiarly distinctive. So much so that during the course of some of Mr. Edison's experiments at Sag Harbor, Long Island, where practice torpedoes were launched, the telephone connected with the detecting apparatus could be laid on the deck and the noise of the torpedo could be plainly heard all over the ship. In fact, the torpedo is the noisiest craft that sails the sea, and is very distinctive and unmistakable.

During the course of Mr. Edison's experiments on detection by sound he had the use of several small steamers, one at a time, which were placed at his disposal by the Government for these experiments. Unfortunately, these respective vessels were not in the best of condition and were laid up for repairs at frequent intervals, and just as Mr. Edison had completed the last experiments above named and had devised very sensitive apparatus to replace direct listening, the vessel was withdrawn by the Government and no other substituted, which, of course, put an end to the work.

QUICK TURNING OF SHIPS.

In connection with the listening device on board ships, Mr. Edison desired to provide cargo boats with a means of turning the ship very quickly to a right-angle course on hearing the launching of a torpedo by his listening device. He believed he could accomplish this with sea anchors. A sea anchor is a device used for arresting the speed of a vessel on the high sea. It is a strong canvas bag, conical in shape, having two ropes attached, a heavy rope to the larger, or mouth, end and a small rope in a slip noose to the smaller, or tapering, end. The heavy rope is secured to the ship. When cast into the sea the mouth opens and the water fills the bag, thus causing it to act as a drag, which arrests the speed of the ship. When the occasion for the use of the sea anchor has passed, the small rope is pulled, which opens the smaller end, and the resistance immediately ceases. The bag can then be hauled on board.

Mr. Edison carried out a number of successful experiments on comparatively small boats, and then arranged for a life-sized test with a 5,000-ton ship loaded with 4,200 tons of coal.

Mr. Edison's plan included the use of four sea anchors each about 9 feet in diameter at the mouth, and each attached to a 4-inch rope.

The plan was to fasten the ends of these 4-inch ropes securely in the bow of the ship and to have the sea anchors placed at the end of the ropes and midway of the ship. If the observer at the listening device reported a torpedo launched by a submarine at a distance, the signal was given and the four sea anchors were to be immediately released and thrown overboard and the helm thrown hard over, bringing the ship almost to a standstill and turning her at right angles to her original course within a very short space of time and advancing only a short distance on her original course.

It will be seen from a copy of the following report that a loaded vessel 325 feet in length was turned 90° from her course in 2 minutes 10 seconds, with an advance of only 200 feet, by the use of only four sea anchors.

The turning curves made on the test above referred to are shown graphically.

U. S. S. "SACHEM" (S. P. 192),
New York, N. Y., September 4, 1919.

From: Lieut. W. S. Harris, U. S. N. (R).
To: Thomas A. Edison, Esq.

Subject: Turning curves U. S. S. *Clio* with and without sea anchores.

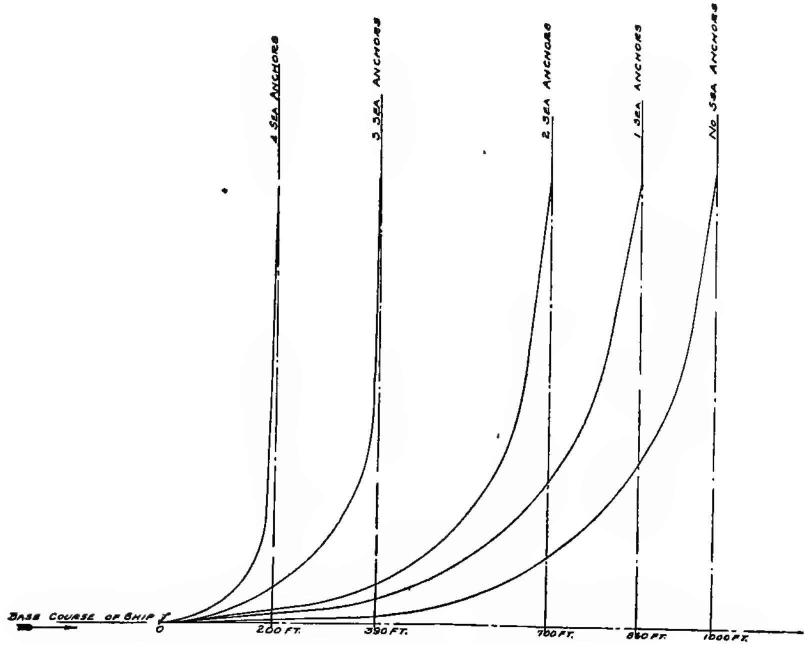
1. On August 22, 1918, the Division of Operations, U. S. Shipping Board, at New York, furnished the U. S. S. *Clio*, in command of Capt. J. Jeffers, master,

for your experiment with the canvas sea anchors to be used in stopping the advance of cargo ships. Below is a table of curves taken from bearings on two buoys at Blue Fish Shoals, in Long Island Sound:

Number of sea anchors.	Advance in feet.	Advance in per cent of advance with no anchors.	Turning time, 90°.
	Feet.	*Per cent.*	*m. s.*
0	1,000	100	2 10
1	860	86	2 3
2	700	70	2 7
3	390	30	2 28
4	200	20	2 10

2. This vessel was loaded with 4,200 tons of coal, her length 325 feet, draft loaded 19.60 feet. This experiment was carried on in slack water under very favorable conditions. The inclosed blue print gives the actual curves.

W. S. HARRIS.



TURNING CURVES U.S.S. CLIO— WITH AND WITHOUT SEA ANCHORS

STRATEGIC PLANS FOR SAVING CARGO BOATS FROM SUBMARINES.

After a few months of experiments on listening devices, Mr. Edison concluded he would leave the experimenting for discovering submarines to others, and conceived the idea that it would be more economic to save the ships from being sunk, if possible. He, therefore, increased his studies by adding camouflage and strategic plans.

He therefore went down to Washington with three assistants, intending to make a thorough study of the statistics of submarine activities and their results, and to develop therefrom strategic plans according to some ideas that he had in mind. He expected to find on the Government records understandable and full details, charted, of the sinkings that had already taken place. Not finding this, he and his assistants worked day and night to prepare the charts and data.

From a study of these, it was quite apparent that the steamship companies had been sailing their vessels on the same routes as before the war. From the statistics of the numerous sinkings it appeared that only about 6 per cent of the ships had been sunk at nighttime. It was a fact, also, that a vast number of troops had been transferred between England and France at nighttime without any loss. It was also apparent from the statistics of sinkings that the steamship companies had not learned the lesson of night sailing in the danger zone. From an examination of Lloyd's Register it appeared that only about 4 per cent of the first-class British merchant ships had modern sounding apparatus aboard, and at that time wireless apparatus was almost unknown on board the British merchant ship.

With all these facts and this data before him, Mr. Edison commenced to work out his plan, which, broadly stated, was for the ships to sail in and out of the danger zone at night; to forsake as much as possible the old standard lines of travel; to anchor through the day in comparatively shallow waters and harbors where submarines could not approach them, steaming only at night to other ports of anchorage on the way to their ultimate destinations.

In order to present this plan in concrete form, Mr. Edison made a study of the statistics of shipping passing in and out of British and French ports for a year, and from the information thus obtained he made a graphic chart. He then obtained a full set of Pilot Books covering the British Isles and France, and charted the harbors in which there was safe anchorage for a long distance inshore in comparatively shallow, but safe, waters, where submarines could not approach submerged.

The results of Mr. Edison's work are embodied in a report which he made in November 1917, and in the maps and charts therein referred to. Copies are hereto attached.

Mr. Edison pursued the same line of work, and in December, 1917, completed and handed in similar strategic maps for handling United

States coastwise and foreign shipping in case any of the submarines appeared on our coast. These were made after Mr. Edison found that no bureau of the Government, even the Bureau of Information, had any statistics of the sailings of coastwise boats in and out of the various harbors. With the assistance of Secretary Redfield and his assistants approximately accurate data was finally obtained through customs officials, harbor masters, and from many other sources. These strategic maps were delivered and explained to the officers of the Bureau of Naval Operations at Washington. Copies of these maps and charts are also attached.

Mr. Edison also made a pegged board covering a chart of the channels and coasts of England, Ireland, and Scotland. This chart was laid off in squares of 40 miles each, which is the approximate visibility of smoke from a cargo boat as seen from a submarine in the center of the square. Each square was provided with a peg and a peg hole. One person had the problem of taking into British or French ports, say, 30 vessels. His opponent had a similar pegged board with 13 pegs representing submarines. The first player routed his ships to the various ports at various hours, while his opponent placed his submarine at points where he thought most likely a vessel would come into his visible area, which was then considered sunk. It was found that by following certain methods these 30 vessels could be brought into port with a surprisingly small number having been seen by the submarine.

Copies of maps and plans referred to in the foregoing pages were forwarded to Sir Eric Geddes, the head of the British Admiralty, November 21, 1917, with the following letter:

I herewith forward some strategic maps prepared for use in diminishing the sinking of cargo boats by submarines.

Map No. 1 shows all the ships which pass in and out of the ports of Great Britain and France in *one day*. The statistics are for 1913, no later date being possible.

From this map it will be seen that the handling of this vast system of traffic in such a manner as to minimize the sinkings requires a man or men of imagination.

Map No. 2 shows at one glance all the vessels and their exact position that have actually been sunk from February 1, 1917, to October 12, 1917.

This map has been compiled from all the data available, given me by the American, French, and English Governments. The maps of these Governments are so many in number and filled with so much general information not directly pertaining to the boats actually sunk, that they are complicated and no human being could ever draw a general conclusion.

Map No. 2 is the result obtained from many maps put on one, and shows the boats sunk by a submarine, without any other matters to confuse the mind. The smaller maps, 3, 4, 5, etc., illustrate the stragetic plans.

STRATEGIC RECOMMENDATIONS.

First. Send cargo boats across to France, or along the English Channel only at night. No cargo boat should appear in the channel in daylight.

Second. No cargo boat should enter or leave any English or French port except at night. The whole of the night should be utilized for approaching or leaving the coast and with the least delay and best speed possible.

Third. The density of traffic is very great at certain spots, and very dangerous. Stop this and route your ships to diminish the density, and spread the traffic over the whole coast of France, England, Ireland, and Scotland, as shown in map No. 4 and *not* as now, shown in map No. 3.

Fourth. Shorten the line of traverse through the danger zone as far as possible.

After having passed through one zone and reached an English or French port, do not attempt to pass through another danger zone, but coast by night only to the port of ultimate destination.

Fifth. You have two types of submarines to contend with. The ocean-going submarine, which cruises far off the land in the Atlantic, and the small submarine which only frequent waters of 100 fathoms or less.

By routing the whole of your traffic as per map No. 4, you make it necessary for the enemy to build and operate several times as many ocean-going submarines as they now operate to sink ships at the present rate. As for the small submarines, the passing of the traffic by coasting at night will almost nullify their efforts.

Sixth. It will be noticed by referring to map No. 2 that most of the ships have been sunk in the lanes shown by sailing charts published by the different Governments.

Boats from abroad make the Fastnet Light, the Scillys, or Ushant. Thence by day the captains run by sight from point to point along the coast, and at night by the lighthouses. The Germans knowing this, place their submarines in this line and enfilade them.

You will note that in mid-channel, between the Scillys and the Bristol Channel and Irish coast, scarcely any ships have been sunk on account of the captains of ships clinging to the old sailing lanes.

It is not necessary for submarines to cruise around to find ships, as has been assumed. This would be a waste of oil when ships are so plenty. Submarines do move around, probably on account of the destroyers and chasers, but not by reason of not finding boats to sink.

Seventh. I find that up to June 1, 1917, only 19 per cent of the cargo boats going in and out of England and France had any wireless. I suppose this has now been remedied, otherwise it diminishes greatly the value of the destroyers.

But what is more serious—and absolutely necessary in order to work strategic plans—is the installation on each cargo boat of a modern wire and tube sounding apparatus. With this the boats can be continuously making soundings without lowering their speed, thus determining their position by means of the hydrographic charts and enabling them to make anchorage at a good port under any condition of weather or gale without running for some sight point, like the Fastnet.

I am told that only naval vessels and some of the very large cargo boats have this sounding apparatus. The cost is small and the operation simple, and I strongly urge that *all* boats should be supplied with them by the Government.

Eighth. If you can partially blind the enemy, you have him at a great disadvantage. If you can blind him entirely, you have him whipped. These night operations are, of course, equivalent to a camouflage of high efficiency. The camouflage can, of course, be carried on, in a measure, when running through the danger zone in daylight; but not if bituminous coal is to be used on cargo boats. The smoke makes the use of a large number of submarines by the enemy unnecessary.

Eliminate the smoke and, all other things being equal, the number of submarines necessary to get the same number of sinkings must be doubled. Cut off the masts, which are no longer of any use; cut down the smokestack to a minimum; close the gaps between the various deck constructions on the ships by canvas to make an even contour, and a still further number of submarines will be required. In addition to this, all boats which cross the danger zone in an easterly or westerly direction should sail in line with the rays of the sun, or what I call "shadow sailing." Shadow sailing is sailing to keep the bow or stern of the boat as near as possible to the sun. Map No. 6 shows the direction and mileage in the summer and map No. 5 in the winter.

The advantage of shadow sailing is that it lends itself to camouflaging devices. It will be noted by referring to maps No. 5 and No. 6 that the loss of carrying capacity for a round trip is very, very small when shadow sailing is followed.

I will furnish you with camouflaging devices later on. I shall go to sea next week to perfect them.

In map No. 18 you will find a plan whereby night camouflaging is carried to the limit. When a boat arrives, say, 250 miles from the port which she intends to enter, it should be in the evening. She then runs all night, and at the break of day she will stop. There will be several ships, if convoy system is used, and at this point the destroyers meet them.

They keep up steam and move at, say, 2 knots an hour in a narrow area, say, of 10 miles, surrounded with destroyers, cruising at required speed. A very small amount of American or Welsh anthracite or gas-house coke should be used for a few hours when sun is bright enough to show smoke. Oil-burning destroyers only to be used, no smoke being emitted.

As night comes, the cargo boats proceed to the second and final night run without destroyers. Outgoing boats should proceed from one harbor and ingoing to another, or all inbound boats go in one day and outgoing another day. This would prevent collisions, as an 11-knot boat would not bump very hard into a 10-knot boat, both going in the same direction. It also becomes unnecessary to have any lights whatever, as there are no destroyers with the boats at night. Zigzagging is unnecessary at night, hence cargo boats could make their normal speed.

At first thought it would appear that half a dozen cargo boats emerging from the night and practically stopping would be dangerous although destroyers were cruising in close proximity, but a device which I have made for determining the number of cargo boats sighted by submarines in various unknown positions shows that when a boat is about to enter a zone in which there is one or more submarines and proceeds 120 miles through such a zone by daylight, it is far safer to stop still in one-twelfth of the zone than to pass through the whole of it. The chance of being sighted is very much smaller.

Of all cargo boats sunk, less than 7 per cent have been sunk in the dark. You will note considerable sinkings around Hull. The boats for Narvik for ore should go in and out at night and spread themselves as much as possible. I have a plan in mind of which I will send particulars if you are interested.

I think that boats arriving at and leaving ports along the East Coast should also run only at night.

All these schemes apply only to the 10 and 11 knot cargo boats. As to the fast steamers, they are in a much more favorable position if this strategy is adopted.

While I have no information, I suspect that you have passed these fast steamers across the English Channel *by night*. Otherwise I can not understand why you bave been so successful with troop ships.

I suggest you establish a routing office coordinating with the American and French. This office should be open at all hours, running three shifts—two men on duty per shift. One of these men should be familiar with the technique of navigation; the other a bright, successful business man, and both young. The office should have wireless and regular telegraph and telephone connections and operators.

It is probable, in fact certain, that if the statements I have made are put up to the average naval officer, he will at once make a lot of objections, because these views differ from his previous experience, or, possibly, from a lack of imagination if my statements do not appeal to him. In such a case, I would request that such objections be reduced to writing, signed by the objector, and forwarded to me for answer.

I will send other suggestions for *hunting* submarines, especially a scheme for employing your submarines to great advantage for this purpose, but I must first try some further experiments at sea.

COLLISION MATS.

One of the schemes suggested by Mr. Edison to minimize the loss of torpedoed vessels covered the launching of collision mats according to a plan submitted to Washington. His arrangement contemplated the installation of 10 collision mats on each side of the vessel, each mat to be 40 feet long and 35 feet wide and rolled on a 6-inch pipe. Photographs of torpedoed ships furnished a clue to the best size for mats. These mats when rolled up and when not in use to be placed about 15 feet away from the sides of the vessel, so as not to be affected by the explosion and out of the way of interfering with the launching of lifeboats. These mats were so arranged that any one of them could be launched in 15 seconds in such manner as to cover the hole made by the explosion.

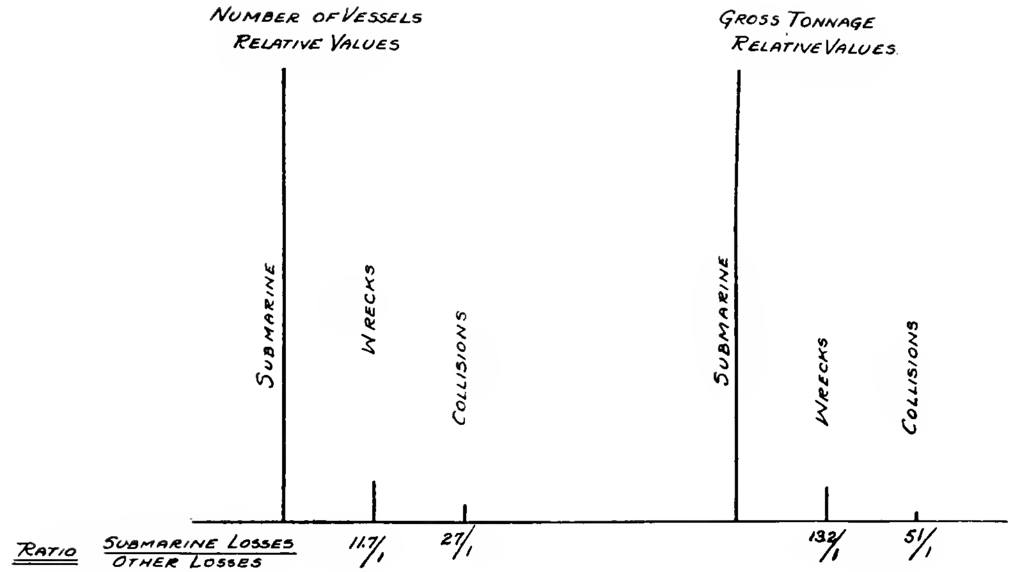
Mr. Edison built a rough model of a merchant ship on a scale of 1 in 25, on which the above plan was carried out on a small scale.

He also launched a 10 by 10 foot collision mat from a boat at sea as an experiment.

TAKING MERCHANT SHIPS OUT OF MINED HARBORS.

A plan was devised by Mr. Edison and submitted at Washington for taking merchant ships out of harbors liable to be mined by submarine mine layers. This plan as proposed would utilize small submarine chasers otherwise lying idle.

The plan was to use two chasers running in parallel, 600 feet apart. Between is a small steel cable, say, one-eighth inch in diameter, se-



Shipping Losses
Steam Vessels

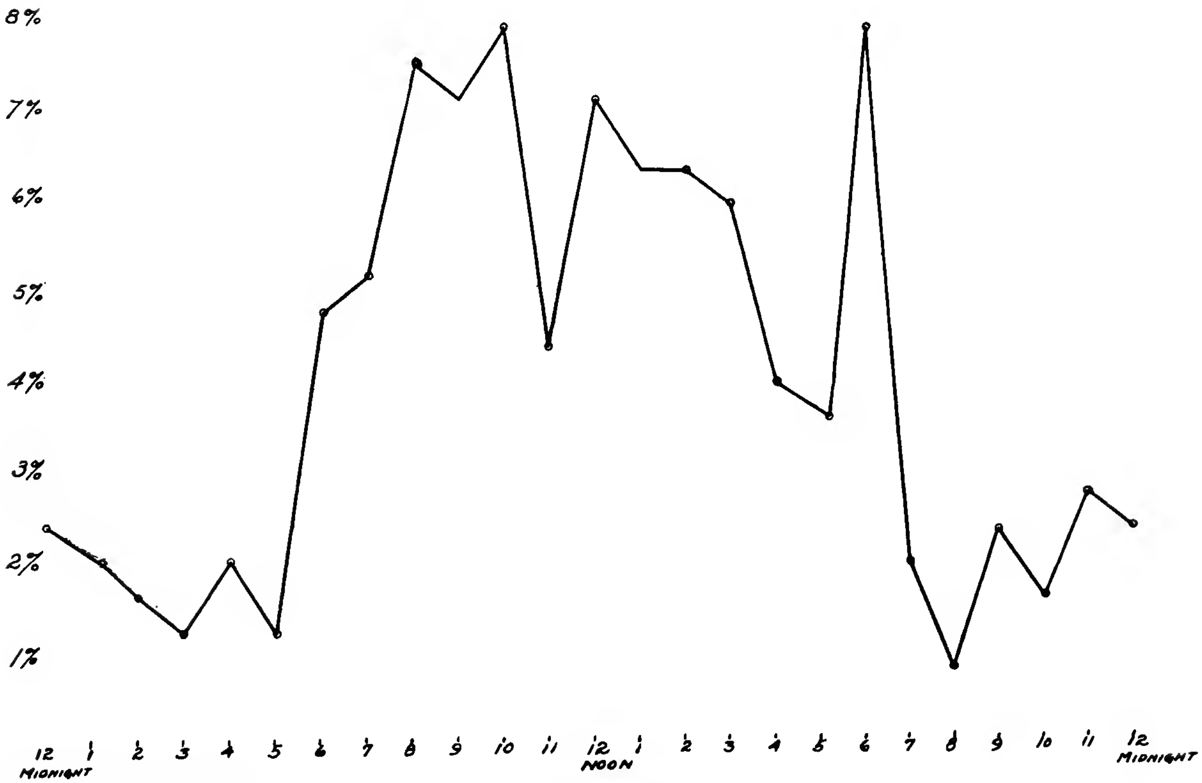
Wrecks and Collisions 1911.
Report of U.S. Commissioner of Navigation

Total No of Vessels	16,013	Tons 26,681,680
Loss by Wrecks	96	173,635
" " Collision	42	46,012

Submarine Losses 1917.

Total No. of Vessels	17,037	Tons 30,539,706
Losses (1917)	1200	2,640,000

Based on sinkings along British + French Coast Feb. 1 to Oct. 1-1917.



Curve Showing
% of Ships sunk in each hour
months of Feb. + Mar. 1917.
(Steamers only)
Atlantic Coast + Channels

cured to each boat. The chasers proceed to sea followed by the merchant ship or ships about half a mile astern and sailing midway between the chasers. If an obstruction is met the chasers throw a buoy to mark the spot and endeavor to get through in another direction. The merchant ships, of course, stop on signal. Should the merchant ships reach the sea where it is improbable that mines exist, the chasers return to port and notify the regular mine sweepers, who proceed to the buoy and investigate the obstruction. This apparatus was sent to Guantanamo, Cuba.

CAMOUFLAGING SHIPS AND BURNING ANTHRACITE.

In July, 1917, officials from the Cunard Steamship Co. and the Submarine Defense Association had several interviews with Mr. Edison in regard to means of protection from submarine activity. He visited the steamship docks with a draftsman and after some experiments suggested to the Cunard Co. a scheme of camouflage shown in the photographs. The scheme is further described in a report forwarded by him to Washington. The report reads as follows:

I inclose photographs of an idea which I have given to the Cunard Steamship Co. They are from a model I have made.

The present strongly operated area of submarines is in an area starting from a line drawn from Wexford, Ireland, to Cherbourg, France, and extending out into the Atlantic for 200 miles from Lands End, England. This area is about 122,000 circular miles.

As the distance which the smoke of a steamer can be seen from a submarine is about 20 miles, this gives a visibility area a circle 40 miles in diameter, or 1,600 circular miles.

I have also advised the Cunard Co. to carry 200 tons of anthracite coal and to burn this only in the danger zone. This amount of coal will carry the vessel in and out of the zone, and the only extra expense for this is $275. I have also had the engineers of the New York Edison Co. teach the Cunard engineers how to effectively burn anthracite so there will be no loss of speed with any cargo boat, which type of boat is the only one that I am working on.

By the suppression of smoke, the area of visibility is reduced from 1,600 circular miles down to 400 circular miles. To reduce this area still further, I suggested that masts be removed, as they are no longer used for sails, so as to help the steam power, and also that the height of the smokestack be diminished to half. With the masts removed and the funnels out, the visible area is still further cut from 400 circular miles to 144 circular miles.

In addition to removing masts and cutting the stack, I have added a camouflage line of canvas strips tapering from bow to stern, the highest point being the stack.

In fair weather a boom pole extends out from both ends of the ship, upon which ropes are hung, the distance apart of each rope being more and more as they recede from the ship. This further reduces the area of visibility.

Two cargo boats of the Cunard Co. are being changed over to comply with the model and they will leave for England next week.

The Submarine Defense Association has taken the matter up, and probably all cargo ships will soon make the changes suggested, which I am glad to say is very quickly done and rather inexpensive.

It has occurred to me that if the United States is to build cargo ships, it would save time and expense by leaving off the masts and reducing the height of the stack so it is not more than 12 feet above the general deck. After the war, it is easily extended.

Two very small pipes 2 inches in diameter, in sockets, and provided with very fine guy wires, can be used, but only when wireless messages are necessary in the zone.

There are still further chances of diminishing visibility.

The *Valerie*, of the Cunard Line, was the first ship to be so camouflaged and Mr. Edison was told from outside sources that she ran for about a year by herself, but when put in a convoy was torpedoed and sunk.

It should be said that previous to Mr. Edison's recommendations to the Cunard Co. he had made investigations as to the possibility of changing over from bituminous to anthracite coal without changing grates. This point was definitely settled by actual tests made on voyages of coastwise steamships.

COAST PATROL BY SUBMARINE BUOYS.

In April, 1917, Mr. Edison submitted to Washington a plan he proposed for patrolling the coast with a chain of submarine buoys. The proposition, as submitted, is as follows, and a copy of the blue print referred to is attached hereto:

I herewith submit a plan for patrol of coast from Nova Scotia to Florida, for detecting submarines and following the same and reporting presence of enemy ships; all from 50 to 100 miles out at sea along the edge of the continental shelf of shallow water, 50 to 60 fathoms.

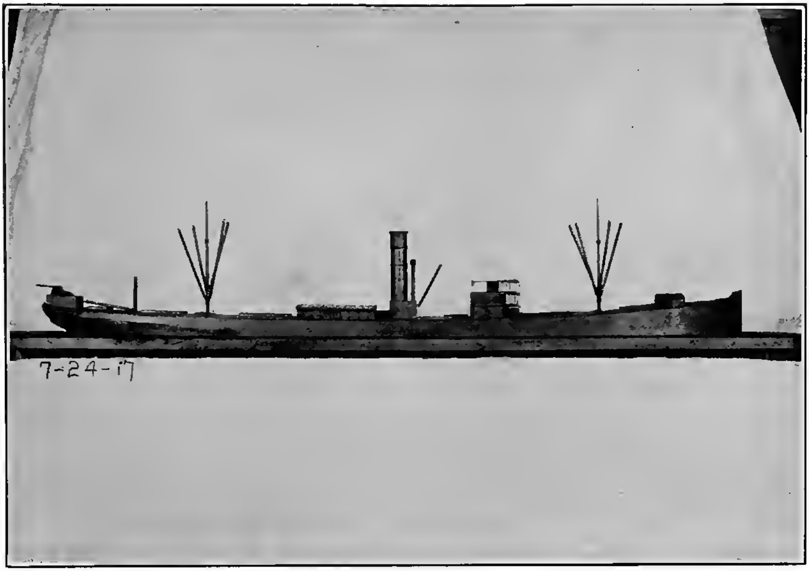
These reporting stations consist of submarine buoys 11 feet in diameter, anchored up to 50 fathoms, resembling in size, make, and operation the Lighthouse Board's whistling buoys. Each buoy is manned by three men, one for each shift. They have wireless outfits for sending under worst conditions 50 miles.

The buoy does not roll to any appreciable extent, but has an up and down motion. The Lighthouse Board experts say they are perfectly practical and will last for years. They state that they know of no conditions of weather that a repair boat can not visit them and go aboard within a week.

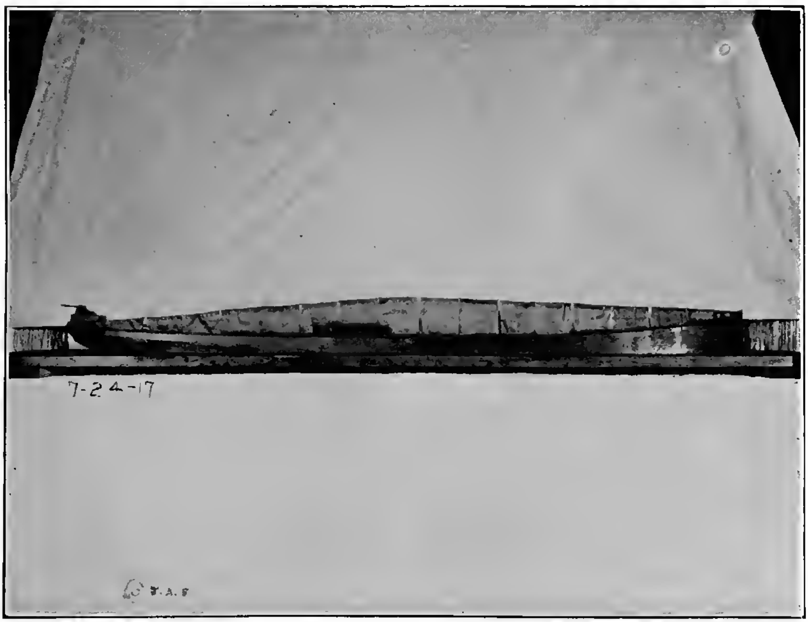
The buoy can submerge to 100 feet or more. Compressed air is used to submerge by water-displacement method. A 2-horsepower air compressor is used for compressing air to either 1,000 or 2,000 pounds in cylinders, capacity three submergings daily.

A sound apparatus is used for detecting submarines or surface vessels and approximately locating their position at all times while in the area or zone patrolled by the buoy. The sound receiving apparatus is lowered to considerable depths where the sound waves are very much stronger than at the surface.

The buoy contains tables for the wireless apparatus and electrical parts of the sound detecting apparatus. It also has bunks for the men, four weeks' supply of food and water, and cooking apparatus. It is lighted by storage battery. A small direct and alternating current dynamo is connected to air compressor engines.



VESSEL NOT CAMOUFLAGED.



SAME VESSEL CAMOUFLAGED.

Seven full days' supply of gasoline is carried in a tank outside the buoy proper, sufficient for most abnormal conditions.

It is contemplated that the buoy will normally be on the surface of the sea. Therefore, except in a storm, the men (except man on duty) can be out in the open air. This buoy will be a very comfortable place for the men. If they are relieved every two weeks it should be sufficient, having shore leave one week.

While watching in daytime, it is believed the detector will warn of presence of top ships or submarines before they can be seen. If in danger of being run down by top ship or being shot at by submarine, they can submerge out of danger.

At night they will also be forewarned by sound detector and submerge and save themselves from being run down by a top boat running without lights. They will also know when they can safely come to the surface.

The cost of these buoys complete should not exceed $8,000 each. The area which each buoy can patrol is at present unknown and will not be known until my experiments, together with those of Mr. Fessenden and others are known. I am very confident of a circle 5 miles in diameter, but until more is known about the sounds given out by a submerged submarine, everything is uncertain.

I feel sure Fessenden will do as well as I can, and perhaps exceed anything I do, as he has actual experience in this line. However, I am confident that between us we will get what is desired, or partially so.

One defect of underwater sound patrols is the great roar set up by white-caps in storms. This will seriously diminish the patrol area, without the use of a little oil in the area.

The buoys could be manufactured very rapidly. There are at least 300 small boiler shops in New York and Pennsylvania who could make them, perhaps one each per week, if they have material. All the appliances are simple and could be made quickly.

After the war these buoys could be partly stored, partially used for small lightships and for whistling and lighting buoys.

I inclose a hydrographic map where I have drawn a line of buoys with the position of the high-speed armed boats.

The lines of buoys are 12 miles apart. There are four rows, in many places less. Each high-speed destroyer or other armed boat attends to an area of 30 miles in every direction; so after position of a submarine is sent by wireless, the armed boat can reach the spot in one hour. If more boats are used then, of course, they can reach the position quicker.

Perhaps the position of buoys is not the best. However, all the data is here, and any disposition can be made of them, and more or less buoys and armed boats used. This scheme is only in the rough and made without any pretention to naval strategics.

If this scheme has any merit to the Navy experts, I suggest a full-size working buoy be made and actual tests made with it in 50 fathoms, so in storms, etc., defects, if any, can be found, and from this it may be changed and used as a model to build others.

In addition to the armed boats there should be a fleet of supply boats; it is estimated that one supply boat can visit three buoys daily.

It is evident that the size of the buoy might be increased to 15 feet diameter and provide for two or more torpedo tubes on a swivel just below the water line, and also for a cannon on the superstructure, just above the water line, and provided with a water break for recoil. But I think its best function is to act as a signaling station only. It will be noticed by referring to the map that there are a few gaps where it is impractical to use buoys on account of the great depth of the water. In this case boats would have to be substituted and maintained in position by occasionally starting engines. There is very little hope of detecting submarines at any considerable distance when a boat is moving, as the jar of machinery sends out sounds locally which can not be compensated for sufficiently to hear the weak sounds from a distance. This is what gives the fixed buoy its great value, in addition to its cheapness of cost and operation.

Data on submarine buoy, accompanying letter of Mr. Thomas A. Edison, April 16, 1917.

Designed for submerging 80 feet—33 pounds of external pressure.
Safety factor of 4.
Frame figured to stand total external load.
Plates figured to stand only external pressure on their unsupported areas.

	Pounds.
Estimated total weight, including everything except the weight of anchor chains	44,000
Estimated weight of ballast water	24,300
Total	68,300
Total displacement when submerged	66,000

As total weight exceeds total displacement, it is therefore possible to submerge without chain, or with minimum chain.

Maximum downward pull of chain and currents, etc., will vary from a few hundred pounds in shallow still water to 18,000 pounds in deep water with strong currents. We then have—

	Pounds.
Weight of shell	44,000
Weight of chain, etc	18,000
Total	62,000

And as this is less than displacement (66 000) it is possible to rise when ballast water is forced out.

Equilibrium.—When water is admitted to ballast tanks until buoy is awash, a very small quantity more will cause it to submerge and (if it were not for *the anchor chains*) continue to submerge until compressed air is admitted ejecting some of the ballast water.

As soon as this is done it will reverse and start to rise, and thus be in unstable equilibrium.

But as the buoy submerges, *the anchor chain* (*whose length is three times the depth of water*) will exert less downward pull, as it becomes shorter; that is, a greater portion of the chain will rest on the bottom. This reduction in the weight will tend to cause the buoy to rise. Thus we can reach a point of *stable* equilibrium where the admission of a few ounces of water or air will cause the buoy to go up or down until balanced by the changed weight of the chain.

CARTRIDGE FOR TAKING SOUNDINGS.

The latest suggestion made by Mr. Edison to Washington concerned a small depth bomb which he had produced after experimentation.

The object of the cartridge is (1) to enable the navigator to ascertain whether there is a safe depth of water under his vessel, and (2) it may be used for safety signaling in fogs. In both cases it is assumed that the listening device in the bow of the boat is used.

The plan proposed is to expel these cartridges from the bridge. They are of two kinds, one made to explode at any given depth, and the other to explode on touching bottom, irrespective of depth. If, for instance, a cartridge is set for 40 fathoms, it will explode when it reaches that depth. The other type will explode only on touching bottom. In this latter case the depth can be ascertained by a time table previously calibrated by experiment.

In either case the explosion may be easily heard a mile or more away at the listening device, the time of expulsion and explosion showing the depth on a recording instrument.

These cartridges can be made about the size of a shotgun cartridge and produced cheaply.

SAILING LIGHTS FOR CONVOYS.

When the system of convoying a number of merchant ships came into vogue there arose a demand for a safe sailing light for use at night. The requisite for such a light was that while it should be visible to all the other vessels of the convoy, including destroyers, it should not be visible from the deck of a submarine sailing on the surface of the sea.

Mr. Edison devised an apparatus to fulfill this requirement. It consisted of several flat disks about 18 inches in diameter, painted a dead black and separated by only one-thirty-second of an inch space. In the center, so as to show a light between the disks, was placed an incandescent lamp of 6 candlepower. Ordinarily, even such a device, suspended on a mast or otherwise, would move in a manner corresponding to the roll and pitch of the ship, and in a rough sea would betray the presence of the ship to the enemy. To overcome this trouble Mr. Edison included as part of the device a gyroscope actuated by a small electric motor. With this addition the sailing light would be always maintained in a horizontal position irrespective of the motion of the vessel, the beams of light being parallel, rendering the light visible only to the observers on the other convoy vessels, all their observations being made in the crow's nest and at a much higher altitude than the deck or periscope of a submarine.

Preliminary tests were made in Chesapeake Bay and showed the principle to be correct.

An electrician from one of the United States submarines had been detailed to assist Mr. Edison in these experiments, but while the

the work on the perfected model was in progress he was withdrawn and was not thereafter returned to help in the completion of the device.

SMUDGING SKY LINE.

In connection with Mr. Edison's numerous experiments with smoke shells, smoke decoys, smudging, etc., he suggested a plan of smudging the sky line with black smoke 3 or 4 miles behind the ships of the United States or Allies if engaged in a naval battle with the enemy, thus enabling our ships to maneuver or change formation without being observed by the enemy. Another advantage was that the enemy at long distances would be unable to get the range, while enemy ships would be clearly visible to us against the sky line.

It will be readily seen that this is not the same thing as a smoke screen, which was frequently used during the war.

In this connection Mr. Edison made some experiments, using boarding 8 by 12 feet on a sky line. The boarding was painted dead black. An observer was placed about 6,000 feet away, using the unassisted eye and also a telescope. Mr. Edison had procured 11 pieces of cloth, each of a different color or shade, and at the blackboard he placed a man who wrapped himself entirely in these sheets of colored cloth, successively, and walked on the sky line and then up and down in front of the blackboard. In all cases the man was visible to the eye when he walked on the sky line, but with cloth of rather dark shades he was invisible by either eye or telescope when in front of the blackboard.

OBSTRUCTING TORPEDOES WITH NETS.

Previous to the time that Mr. Edison evolved the idea of the quick turning of a ship to avoid an oncoming torpedo, as described heretofore, he was experimenting on a plan to enable merchant ships to escape torpedoes launched at them by submarines.

Part of this plan was to use his listening device, by means of which a torpedo could be heard the moment it was launched. Mr. Edison proposed the use of a simple gun, similar to a trench mortar, from which should be fired an obstruction netting. This consisted of a small flotation tube, say, 25 feet long, over which is wound a net of 1-foot mesh made of quarter-inch cable of very fine steel wires, the net being coated each side with thin canvas. The whole would resemble a large window shade. When the net strikes the water it unwinds and extends down 25 feet.

The plan was that if the torpedo were heard advancing toward the boat a large number of these nets should be thrown in its path, giving sufficient retardation that it would be stopped or be so delayed as to miss the ship.

TEST OF OLEUM-CLOUD SHELL.

STEAMSHIP DECOY.

The powder suggested for the guns was very slow-burning, of a special character to give a mean effective pressure, possibly of 200 to 400 pounds per inch. In Mr. Edison's experiments he gained sufficient data to estimate that these nets could be delivered at least 950 feet from the boat. The rolls did not tumble, but could be fired with remarkable accuracy.

UNDERWATER SEARCHLIGHT.

One of the problems placed before Mr. Edison was to provide a searchlight to be used under water by submarines.

At his request the New York Testing Laboratories made some experiments on arc projectors giving light of different wave lengths through long tubes filled with sea water and distilled water. Their facilities were not adequate for the extended experiments Mr. Edison desired to make on the absorption of light by sea water, and he continued the work in his laboratory, using arc lights with combination carbons carrying elementary substances.

After making a great number of experiments he found that the green line of barium in the arc penetrated salt water farther than any other he had observed. It was his impression that in blue water it might be possible to see an object 200 feet ahead with rather powerful apparatus, and so reported to Washington, stating at the same time that he had reached a point where progress could not be made in the laboratory and that further experimenting should be done at sea.

It may be added that his last experiments were with a 60-foot tube filled with sea water, at the end of which sufficient light was transmitted to read print.

In connection with these experiments Mr. Edison incidentally suggested a plan whereby the safest depth of water under a ship could be obtained while running.

OLEUM CLOUD SHELLS.

The experiments with shells containing oleum, which on bursting would form a dense white suffocating cloud, were followed up by Mr. Edison for several months. He was greatly impressed with the desirability of this type of shell for many purposes, especially for making a cloud to blind the vision of enemy ships. Their inexpensiveness, both intrinsic and comparative, appealed to his sense of economy, and their effectiveness was in his judgment desirable for the purpose. The oleum shell was in general of similar construction to other shells but contained a can of oleum instead of shrapnel, and also a bursting charge of T. N. T.

The photograph shows test of this shell at sea.

A year afterwards it was stated that the Germans were using oleum shells toward the close of the war.

HIGH-SPEED SIGNALING WITH SEARCHLIGHTS.

The officials of the Brooklyn Navy Yard having expressed to Mr. Edison a desire for a device which would permit high-speed signaling with searchlights, he proceeded to experiment along this line and produced the device shown in photograph.

This device consists of a Venetian shutter inclosed in a frame, the shutter being connected to an electromagnet in circuit with a battery and telegraph key. The working of the key actuated the electromagnet, this causing the shutters to open and close, and Morse signals could be flashed at the rate of 40 words a minute.

The device was sent to the Brooklyn Navy Yard.

WATER-PENETRATING PROJECTILE.

It is well known that an ordinary projectile fired at sea will, on striking the water, ricochet and will not penetrate the water in a direct line so as to make a penetrative hit on a submerged target. During the height of enemy submarine activity, Mr. Edison also devised a type of projectile which would enter the water direct without ricochet, and which would continue its course without deflection and make a penetrative hit.

His experiments were made at a small lake in New Jersey, using a 1-pounder gun loaned by the Navy Department.

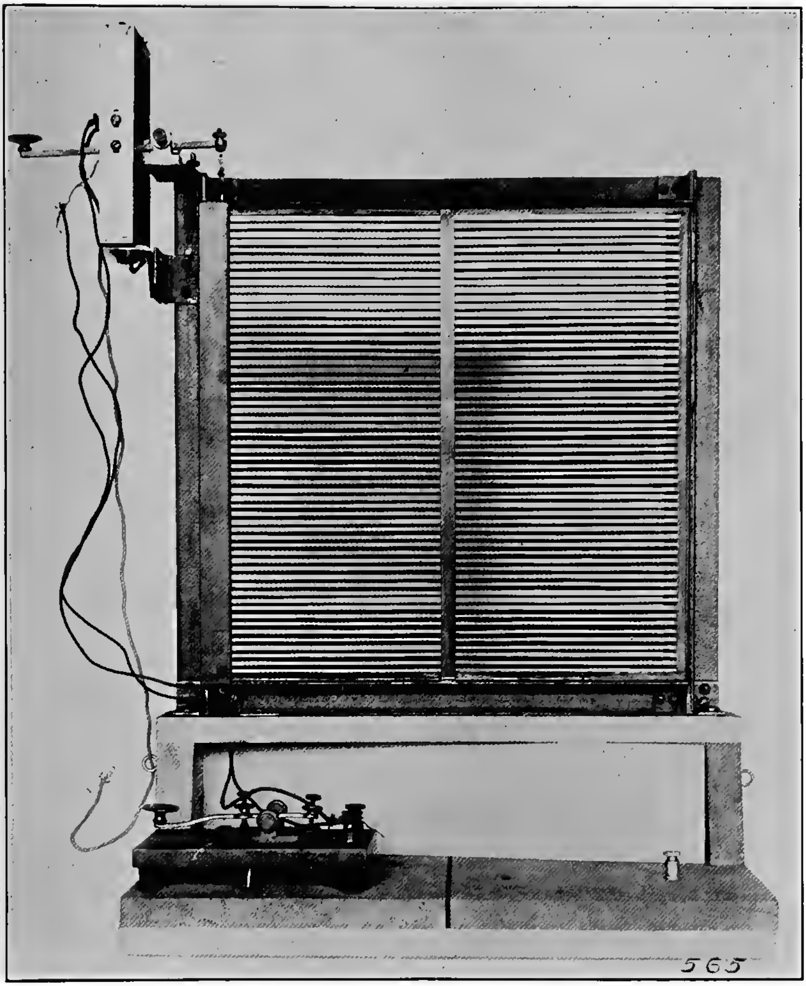
The projectiles used with this gun were, of course, small and were solid, although his plans for actual war practice included the use of larger ones carrying charges of explosives.

The device consists of a projectile of the shape shown in accompanying photograph arranged to be held in a container and fired from a gun of larger caliber than the diameter of the projectile. The container consists of a thin-walled steel cylinder open at the forward end and closed at the rear end by a plug of sufficient strength to withstand the pressure of the gases in the gun.

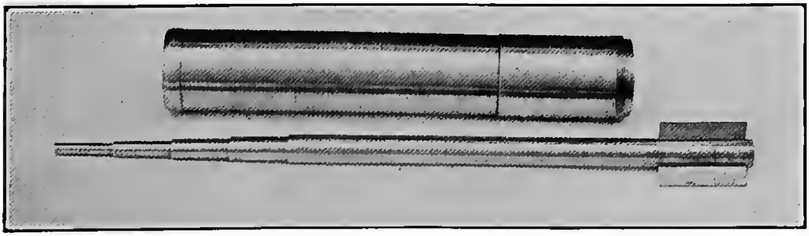
The projectile is held central in the container by means of flat steel pieces extending longitudinally.

At the rear end of the projectile are fixed fins projecting beyond the circumference of the projectile whose purpose is to impart rotation to the device and also to introduce an air resistance force at the base to prevent tumbling of the projectile.

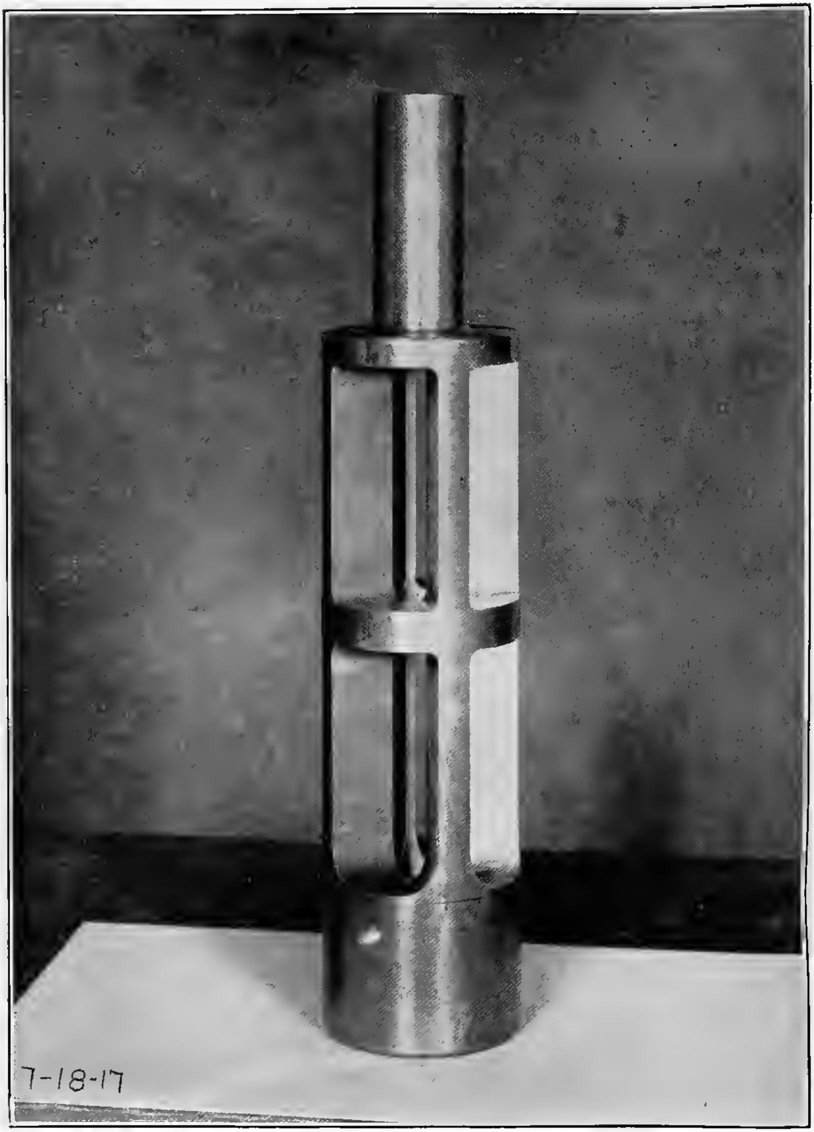
The front end of the projectile is provided with a series of steps as shown. The purpose of this feature is to afford a biting edge



HIGH SPEED SIGNALING SHUTTER.



WATER PENETRATING PROJECTILE.



MUZZLE EXTENSION FOR WATER PENETRATING PROJECTILE.

which will force the projectile to enter water when it strikes the surface of same.

In operation, when the projectile is fired from the piece, the projectile proper and the container leave the gun together. When traveling through the air the container travels slower than the projectile and is left behind. This is due to the much greater air resistance of the container. The projectile fits loosely in the container to readily permit this to occur.

Experiments have shown that the projectile and container become separated before they have traveled 100 feet from the muzzle of the piece (1.5-inch gun and $\frac{3}{4}$-inch projectile).

The advantages claimed for this device are as follows:

1. The projectile may be fired from a standard rifle.

2. The projectile may be fired from a smoothbore gun which is provided with an extension fitted on the muzzle which contains longitudinal slots to allow the escape of the gases gradually and to provide a guide for the projectile in the region near the muzzle where the escaping powder gases have a tendency to deflect the projectile from its true course.

3. The decreased head resistance of the projectile results in a flatter trajectory which increases the danger space, a higher striking velocity and longer ranges than with the present type of projectile.

4. The projectile will enter the water and strike a submerged target with effective results.

The following will be illustrative of the many tests made with this type of projectile. In these tests the gun (smoothbore) was 8 feet 3 inches above the water and distant 324 feet from the submerged target. Three-quarter service charged used.

Weight of projectile, 0.553 pound.

Weight of container, 0.721 pound.

Weight of charge, 57 grams of service guncotton.

Shot No. 1: Water penetration, 7 feet; effect on target, penetrated $\frac{1}{32}$-inch sheet iron.

Shot No. 2: Water penetration, 80 feet; effect on target, penetrated 7/62-inch steel plate and dented 7/62-inch steel plate situated beyond first plate.

Shot No. 3: Water penetration, 100 feet; effect on target, penetrated 7/64-inch steel plate and 1/32-inch sheet iron.

The holes made in the target were clean, round holes indicating projectile had hit same normally.

OBSERVING PERISCOPES IN SILHOUETTE.

At various times during three months Mr. Edison made a series of observations with a view of ascertaining how best to detect the periscope of an enemy submarine. He found that instead of trying to detect a periscope from the deck, pilot house, or crow's nest of a vessel it was far more certain to make observation from a port-hole about 30 inches above the water line, from which position the periscope appeared in silhouette, standing and distinctly, and could be instantly detected.

Of course, he realized that this plan was only feasible when the ocean was not rough.

STEAMSHIP DECOYS.

To give the merchant ship a great possibility of escaping submarine activity, Mr. Edison devised a cheap form of decoy of which a number could be carried on board. This decoy was constructed of thin sheet iron in the form of a water-tight drum having several chambers containing heavy smoke-producing materials. A funnel completed the arrangement. The idea was that on approaching a danger zone the combustion of the smoke-producing material was started and the decoy placed in the water, after which the steamer pursued her course. The decoy with smoke pouring from the funnel would drift about, giving the appearance from a distance of a steamer on the horizon and would tend to attract a submarine and mislead the commander, thus wasting time and effort and tend to reduce his battery charge.

ZIGZAGGING.

In the latter part of the year 1917 the naval officers of the Allies adopted a plan of having merchant ships in zigzag lines when proceeding through a danger zone. Having made many months' study of the submarine question and having collected a great amount of data, Mr. Edison reached the conclusion that it was useless for merchant ships moving less than 10 knots an hour to zigzag and that the results only led to a loss of our total carrying capacity.

This conclusion was transmitted to Washington, accompanied by an illustrative diagram. Mr. Edison learned subsequently that the French naval officers had arrived at the same conclusion.

REDUCING ROLLING OF WARSHIPS.

In view of the difficulty of accurate gunfire by a warship during heavy weather, Mr. Edison realized that a device for stabilization might be worthy of consideration, and submitted to Washington the following suggestion:

Vanes in the nature of diving rudders are installed, one on each side of the ship near the bottom. These are oscillated back and forth through an arc of about 30 degrees above and below the neutral plane. Electric motors running continuously drive through gearing the reciprocating mechanism connected to the vanes. These motors are run at such a speed that the vanes make a complete cycle of oscillation in the same period that the ship makes one complete double roll. The vanes are mounted on a heavy shaft passing through the skin of the ship and are so placed that the pressure is balanced and very little torsion is produced on the shaft. When the ship is running, an upward or downward pressure is produced by the vanes, depending on the angle they make with the horizontal. If this pressure is properly controlled and timed to be in step with the roll, it will tend to extinguish the roll and will introduce a force directly opposed to the forces tending to set up oscillations of the ship.

To keep the oscillations of the vanes in step with the roll of the boat, devices are used which cause the ship's roll to automatically keep the speed of the motors operating the vanes at such a value that the vanes always move in synchronism with the ship's swing. Two semicircular contacts are provided on the rotating shaft driving the reciprocating mechanism. Each of these is connected to contacts located at either end of a glass tube placed parallel to the deck of the ship. A globule of mercury in the tube rolls backward and forward with the roll of the ship and alternately closes and opens the contacts in the ends of the tube. The wiring is so arranged that when there is perfect synchronism between the oscillations of the vanes and the oscillations of the ship no complete electric circuit is made. When, however, the motor tends to run slightly ahead or behind perfect synchronism, a complete electric circuit is made which causes the field strength of the motor to vary, changing the speed slightly to bring the mechanism back to complete synchronism.

Roll is set up in a ship by the cumulative action of wave forces which are in step, or nearly so, with the natural period of the ship. From information and data given in an article in the Encyclopedia Brittanica, it appears that the magnitude of these forces in the case of a battleship in the neighborhood of 500 to 2,000 foot-tons for rolls of about 15 to 30 degrees, or equivalent to about 11 to 45 tons on the sides of the ship (90-foot beam). Vanes or rudders with 100 square feet of surface can easily develop pressures up to about 50 tons at a speed of 20 knots. These pressures, if properly controlled, can be made to extinguish or greatly reduce rolling.

OBTAINING NITROGEN FROM THE AIR.

Some 17 or 18 years ago Mr. Edison was experimenting with the reduction of iron by hydrogen for his storage battery. In May, 1917, he remembered certain phenomena connected with these experiments, and communicated the same to Washington, thinking it might be interesting as revealing a process of obtaining nitrogen from the air, for use in explosives.

The substance of the communication was to the effect that in the experiments above referred to nitrogen and hydrogen were passed over the iron to render it nonpyrophoric. In doing this a considerable quantity of ammonia developed, which was troublesome, but no special thought was given to it. It having appeared that the Germans were making nitric acid from ammonia, Mr. Edison set up his old apparatus again and found that by mixing lampblack with the reduced iron the passage of nitrogen and hydrogen over it produced ammonia continuously in large quantity, which he absorbed in acid.

A remarkable feature, to which Mr. Edison called attention, was that while the Germans were compelled to use high pressure, his process worked at ordinary pressure, and the investment required was exceedingly small.

STABILITY OF SUBMERGED SUBMARINES.

Mr. Edison forwarded the following suggestion to Washington:

Submarines, when submerged, must keep moving to preserve their stability, thus wasting their battery charge when an occasion might arise that they would need all the current possible.

If a drum is put in a recess of the vessel, and controlled by a shaft running into the interior through a stuffing box, a chain may be passed through a hole to the bottom of the sea, 50 fathoms or less.

If, after submerging, say, 25 fathoms, the chain is made three and a half times the distance between the keel of the submarine and the bottom of the sea, the boat will be in equilibrium without moving.

A tendency to rise increases weight of chain, and any tendency to sink lightens the weight of the chain. There will thus be found automatically, the exact place where the submarine is in equilibrium.

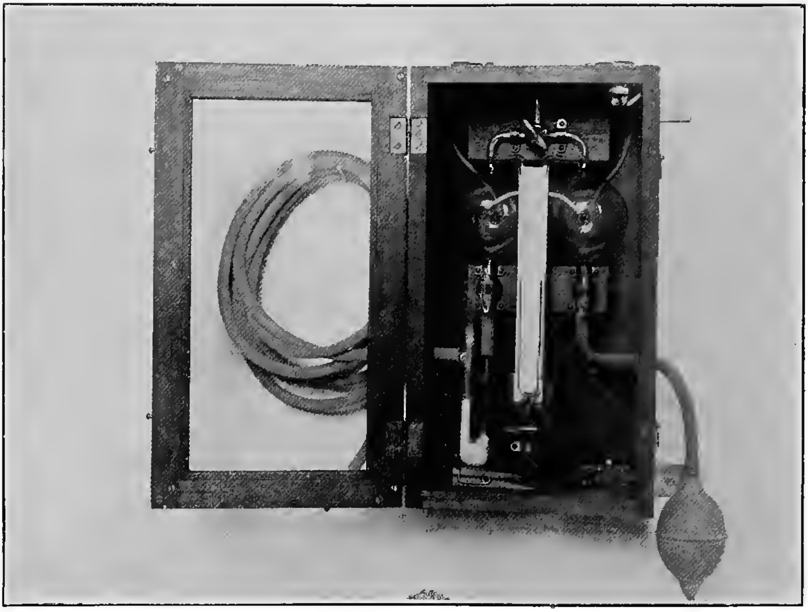
HYDROGEN DETECTOR FOR SUBMARINES.

The various explosions on submarines resulting from an excessive accumulation of hydrogen gas rendered it highly desirable to develop a reliable and simple hydrogen detector. Mr. Edison therefore devoted some thought to this subject and after a series of experiments produced an accurate and simple instrument which would indicate as small a quantity as three one-hundredths of 1 per cent of hydrogen in the atmosphere of a submarine. This instrument could be made in quantities for about $50.

Information relative to this hydrogen detector was forwarded to Washington, but the instrument was deemed to be too fragile. Mr. Edison subsequently placed one of these instruments on a submarine used constantly for maneuver practice. It remained on board nine months and was still all right at the end of that time.

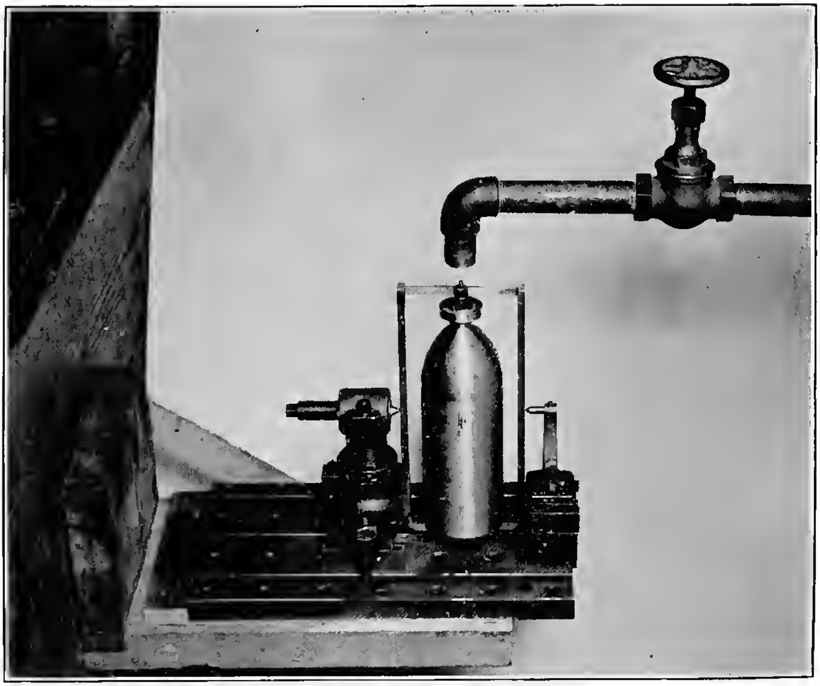
INDUCTION BALANCE FOR SUBMARINE DETECTION.

After more than two months' steady work on the subject and a long line of experiments, Mr. Edison reported that he had no practical success in his endeavor to establish a system of detecting submarines by the principle of the induction balance, with many variations and other means, for detecting masses of iron or steel at a distance.



HYDROGEN DETECTOR.

182–1



TURBINE-HEAD PROJECTILE.

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GAS PROTECTER.

PROTECTING OBSERVERS FROM SMOKESTACK GAS.

Mr. Edison had been informed that, under certain conditions of the wind, splash observers on top of the masts suffered considerably from the gases emitted from the smokestacks of warships, and that the effects of the sulphurous acid from the sulphur of the oil are very severe.

He therefore developed a simple device which upon very severe tests proved its practicability to render the observer immune from the effects of the smokestack gas.

The specifications given to Mr. Edison required that the observer should have hands, ears, and eyes free. These were complied with. The usual mask around nose and mouth was dispensed with, as the Bureau of Mines' representatives in the coal regions advised that these masks were impracticable, as they would not fit all faces.

Photograph of the device is herewith submitted. Mr. Edison personally tested this device by wearing it in a closed room filled with burning sulphur vapors, and experienced no inconvenience whatever.

TURBINE HEAD FOR PROJECTILE.

One of the earliest subjects on which Mr. Edison worked was to produce a projectile which could be fired from a smoothbore gun, or an eroded gun, and still have rotation and accuracy.

After some minor experiments Mr. Edison evolved the turbine head, which was capable of being attached to a projectile and of giving to it any desired speed of rotation through changing the angle of the turbine blades. Having no facilities at first to make any actual gun firing tests he tested a 3-inch projectile fitted with turbine head in the apparatus shown in the photograph submitted herewith. A jet of compressed air impinged upon the turbine head causing it to rotate at varying speeds according to the feed of the air jet. Under these tests the projectile was found to act like a gyroscope and if forced to one side would quickly return.

Subsequently, an old smoothbore 1-pounder gun was loaned to Mr. Edison which he used at a range in the mountains to try out the turbine-head projectile.

In the meantime his preliminary suggestion had been forwarded to Washington, where ordnance experts gave the opinion that the turbine-head projectile when fired from a small-bore gun would tumble.

Mr. Edison made some actual trials with the 1-pounder and reported that while regular projectiles fired from his 1-pounder tumbled badly, those with the turbine head did not tumble under similar conditions.

MINING ZEEBRUGGE HARBOR.

In July, 1917, Mr. Edison suggested to Washington the following scheme for mining the harbor of Zeebrugge:

Use flat-bottom rowboats about 15 feet long, 4 feet wide, having water-tight covering.

In this type of boat is a gyrostat run by a motor connected to the rudder. The propeller is driven by a 2-horsepower motor and a storage battery smaller than that used in an electric vehicle. Fastened to the bottom of the boat is a standard mine with chain. In addition, there is also a pole connected to the bottom of the boat extending down about 26 feet, which is the depth of water just off Zeebrugge Breakwater. When the pole strikes the bottom, it releases the mine and chain and sinks the boat. The pole in question can be set for any depth.

These boats, which only appear 6 inches above the sea, having a rounding top, are very difficult to see with any searchlight at night, hence are not liable to be shot at. The speed of the boat is about 2½ miles per hour.

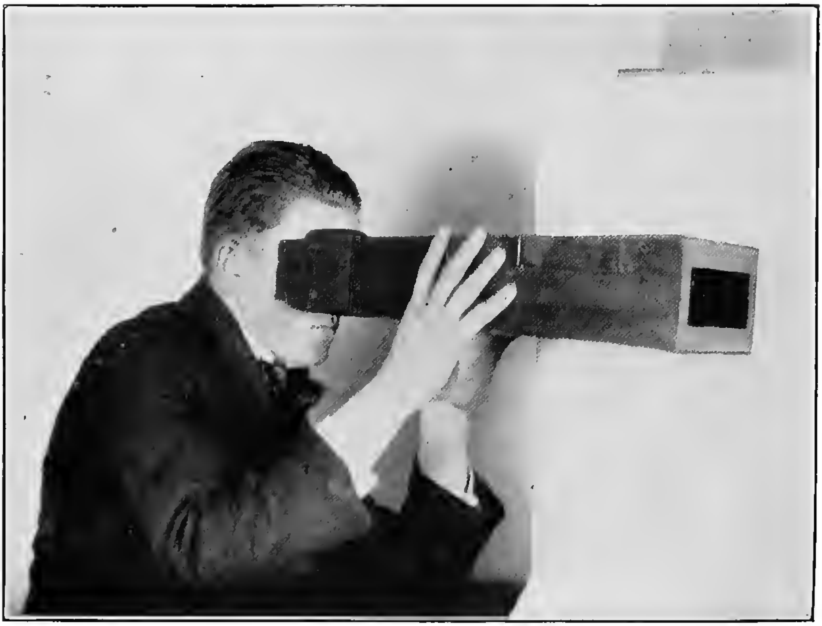
The scheme is that on favorable nights a lot of small vessels approach within, say, 15 miles of Zeebrugge, each boat being provided with a half dozen of these skiffs. Knowing then the direction of the searchlights, tide, and drifts, they can set the gyrostatic rudder and aim the boats for the harbor, inner or outer, and they can do this at all kinds of times. The boats are very cheap.

MIRROR REFLECTION SYSTEM FOR WARSHIPS.

Having been informed that when warships are in action there is danger that some parts of their tube and telephone systems might be shot away or become broken, Mr. Edison was requested to suggest some means of establishing communicating signals through a ship. He reported later some experiments he had tried with beams of light reflected from mirrors. He found that practically any number of corners could be turned with a small loss of light. For instance, a beam of light could be reflected from the masthead, along many passages and decks, around corners and so on to the bottom of the ship.

In one experiment, with a beam of light 300 feet long, the figures 1, 2, 3, after turning eight corners, were plainly visible at the other end; also dots and dashes made by a key tilting the terminal mirror. An incandescent lamp was used.

In Mr. Edison's laboratory a person in the rear part of the third floor could be plainly seen and identified from the front part of the first floor.



DEVICE FOR LOOKOUT MEN.

A criticism was made that on account of the twist and jar of the ship the system of mirrors would get out of alignment and therefore would become valueless. Mr. Edison made further experiments and reported as the result that a ship could twist in any direction 14 inches for every 62 feet of length, and could also jar and twist to any probable extent without impairing communication.

DEVICE FOR LOOKOUT MEN.

A simple little device for use by lookout men in watching for periscopes in bright sunlight was suggested by Mr. Edison. It consisted of a tapering metallic box, open at both ends, fitted with a light-excluding eyepiece, and having diaphragms placed at intervals along its inside length. It was about 14 inches long and its greatest aperture was about 5 by 6 inches. The device was painted a dead black inside and out, and its construction was very cheap.

In practice about 75 per cent of the general glare would be cut off from the eye, allowing the pupil of the eye to dilate and making the vision much more sensitive. By the use of this device in full light of day objects could be discerned that were otherwise invisible.

BLINDING SUBMARINES AND SMUDGING PERISCOPES.

During the great activity of the enemy submarines Mr. Edison devoted a great deal of thought to various plans for preventing sinkings, and he suggested a number of schemes to this end.

One of these was a proposition to furnish merchant ships with a type of specially designed 3-inch shell filled with an oleum smoke-producing compound with which to blind submarines in cases where they had long-range guns, and where the merchant ships were helpless. The principle of the shell proposed by Mr. Edison had been fully tried out by him on land before submitting to Washington the following design.

DESIGN OF SMOKE-PRODUCING PROJECTILE FOR 3-INCH GUN.

Head and base same as in the standard specification.

Shell lengthened 6.68 inches and thickness of walls above diaphragm decreased tapering from 0.3 inch to 0.2 inch.

Amount of bursting charges and volume of bursting charge chamber same as in standard.

Tube to be made of drawn *steel* instead of brass on account of action of acid. Inner tube of copper as in standard.

Diaphragm to be sealed with paraffin wax and interior of shell coated with thin layer of paraffin, where in contact with acid. *No shellac* to be used for coating except in bursting charge chamber.

The weight of the sample tracer is not included in the total weight.

Shell to be exploded by *time* fuze.

Oleum to contain 60 to 62 per cent excess SO_3; may be obtained at that concentration from the General Chemical Co. at its Bayonne, N. J., plant.

Calculated weight of shell and contents:

	Pounds.
Weight of thin walls	8.13
Base	2.18
Driving band	0.15
Diaphragm	0.47
Inner tube (approximate)	0.09
Head	0.45
Explosive	0.17
Oleum (60.1 cubic inches) (approximate)	4.28
Washer	0.02
Fuse	1.25
Total	17.19

Total weight of projectile 1.82 pounds in excess of specified weight of 3-inch shrapnel shell.

On account of lengthening the shell, it may be necessary to use a modified powder train in the tube, or to recalibrate the time fuse.

To overcome any tendency for "tilting" an increase of velocity may be necessary.

(Standard data taken from Shrapnel Shell Manufacturer, by Douglas T. Hamilton, The Industrial Press (1915), pp. 286–292.)

EXTINGUISHING FIRES IN COAL BUNKERS.

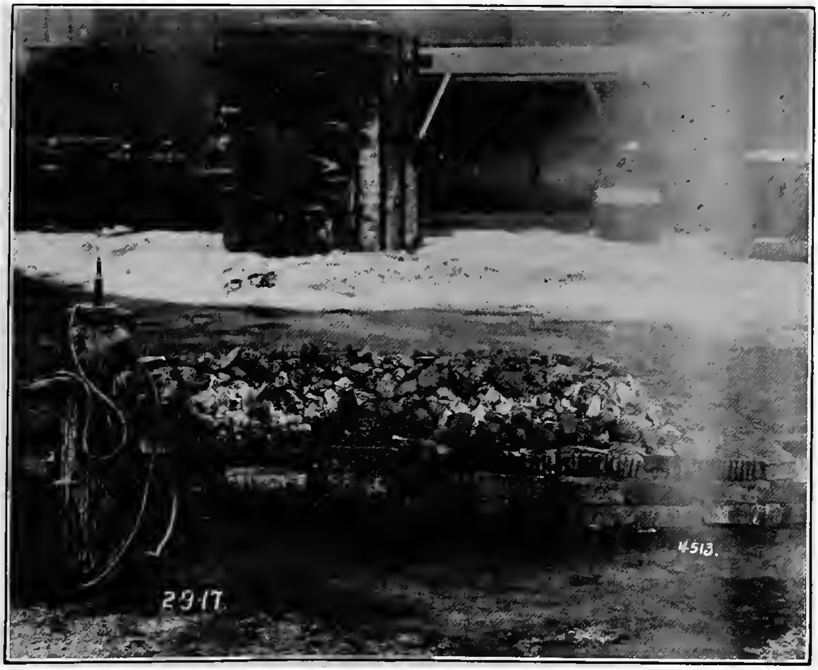
One of the problems submitted to Mr. Edison related to means for extinguishing coal-bunker fires on board warships.

After a series of experiments he suggested that a small stream of silicate of soda played on a coal or wood fire was surprisingly efficient in extinguishing them. The moment the siliciate of soda strikes the incandescent body the small quantity of water in the silicate evaporates and the glowing body becomes coated with a glassy surface, excluding the oxygen and thus extinguishing the fire. Mr. Edison offered to give instructions for the manufacture of silicate of soda, calling the attention of the department to the facts of its cheapness and that all the requirements of the Navy could be made at a navy yard.

Photographs herewith submitted.

DIRECTION FINDER FOR HOSTILE AIRPLANES.

This development work was undertaken to determine the direction of an hostile airplane before it was visible, by determining the direction of the source of sound given off by its engine.



METHOD OF EXTINGUISHING FIRES.

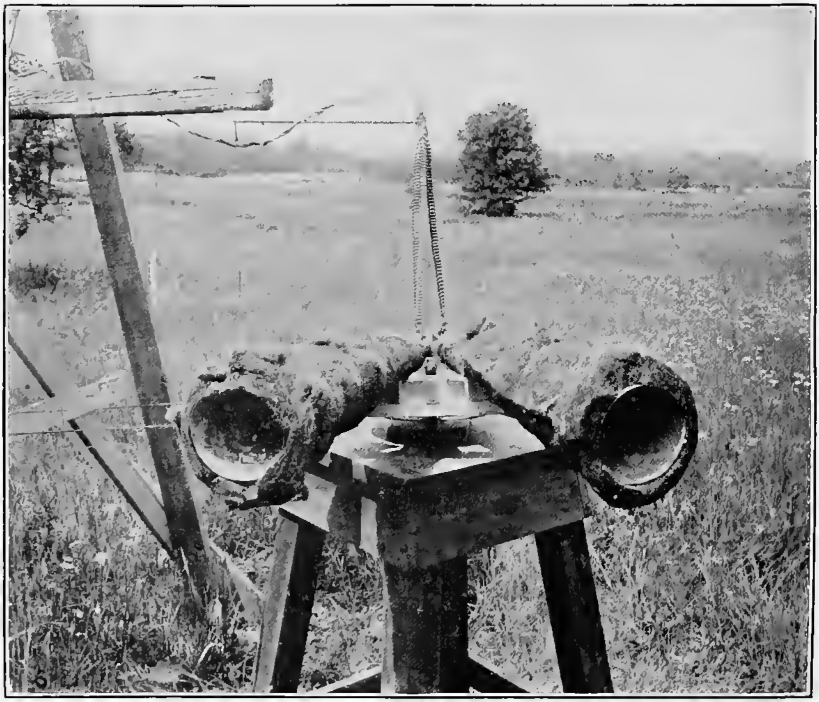


FIG. 1.—DIRECTION FINDER.

Mr. Edison's general plan was to arrange two horns at a fixed angle to one another, arranged to convey the sound to opposite sides of the same diaphragm and to swing the horn system, both in horizontal and vertical planes, until there was no movement of the diaphragm because the sounds conveyed by both horns were of equal value and therefore neutralized one another.

Preliminary study.—Studies were made on the best arrangement of diaphragm which was used in connection with a magneto type telephone circuit, and these studies also included experiments to determine the best arrangement of the magnetic system and sound chambers for the work required of them.

Another series of studies was undertaken to find the best angle relationship between the two horns, so as to get maximum and zero readings when in symmetrical position in relation to the source of sound.

Studies were also made of various forms of horns and reflectors for receiving sound at various distances, in order to determine the best combination for this particular problem.

Apparatus used.—The sound-receiving apparatus (as shown in fig. 1) consists of two horns set on a turntable and conveying sound to either side of a common diaphragm.

The diaphragm in its movement generated or controlled the current which was conveyed to an observer equipped with head band receiver and who was located in a sound-proof booth.

The observer was provided with a graduated disk which operated in synchronism with the turntable holding the horn, so that he could read the position of the receiving horns, and was able to manipulate their movement from the booth.

As will be noticed from the photographs, the horns used were covered with a sound-insulating material, so that sounds reaching the diaphragm were only those entering the mouth of the horn.

Photograph No. 6 shows experiments made with the horn elevated 25 feet from the ground to determine the possible advantage of this method over that of placing the horn close to the surface of the earth.

Tests and results obtained.—It was found very difficult to get absolutely "zero readings," but with some training on the part of the observer the direction could be determined with considerable accuracy.

SOUND RANGING.

The determination of the location of hidden guns by observing the time intervals between which the sound of their discharge reached several known points was early undertaken by Mr. Edison.

His idea was to develop apparatus that could be practically applied in the field and could be relied upon for accurate results under the varying unfavorable conditions that would likely prevail in practical service. He also considered it important to use the shortest possible "base line."

Mr. Edison had already performed a great many experiments with electric magnetic recorders in developing the telescribe, so that he was able to utilize the instruments developed in this study for the recording of gun sounds. It was found that the phonograph method of recording had peculiar advantages for this work.

Preliminary study.—Electrical recording apparatus (shown in fig. 1) was set up, and studies made of the characteristic outlines of gun shots, to determine how accurately the arrival of the sound wave could be registered. Studies were also made of the following:

(1) The effect of obstructions in the path of the sound.

(2) The effect of wind blowing at various angles to the path of sound.

(3) The effect of temperature, humidity, etc.

(4) The effect of refraction and reflection from solid objects and different air strata.

(5) Transmission of sound through the earth.

(6) The emphasizing of the records from the gunshots over other noises.

For the above study the use of a large tract of land near the laboratory was obtained and a great many tests and observations made, with the result that it was found that all of the varying factors that would affect the time intervals between the sound at the various stations could be corrected, or allowed for, within practical limits.

Apparatus.—The following apparatus was developed as a result of the preliminary tests:

Recording machine, which consisted of (as shown in fig. 2), a very substantially built phonograph, provided with three electromagnetic recorders which were capable of accurate alignment by means of micrometer screws. This was driven by a powerful spring motor, so as to be independent of electric current supply, and ran at a very uniform speed.

Reading instrument (as shown in fig. 3), consisted of a mandrel for holding the cylinder, with a microscope mounted for close reading, connected with a finely graduated scale so that relative time intervals between sounds could be very quickly and accurately obtained.

Timing apparatus consisted of electrically operated tuning fork, which made a record of 517.3 periods per second. This was a special arrangement developed for the purpose, and gave much finer divisions than could be obtained with any commercial timing device that was available for the work.

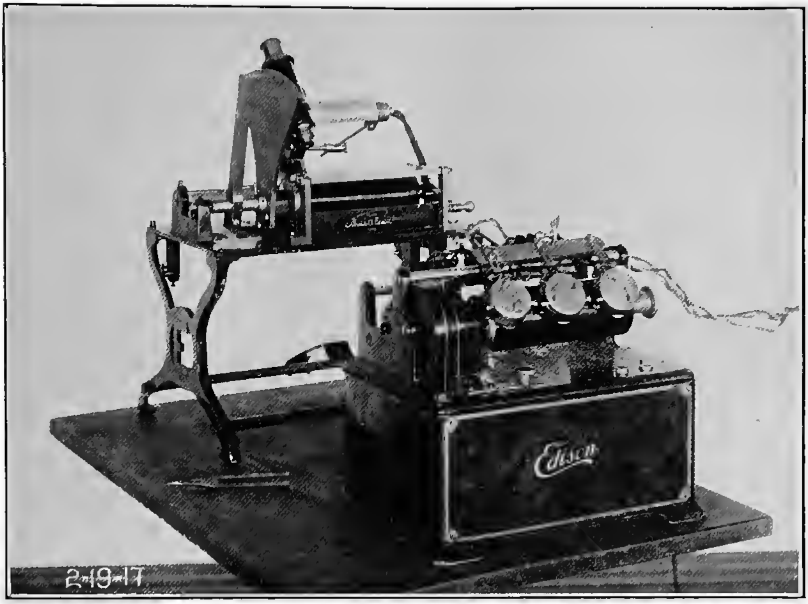


FIG. 1.—ELECTRICAL RECORDING APPARATUS.

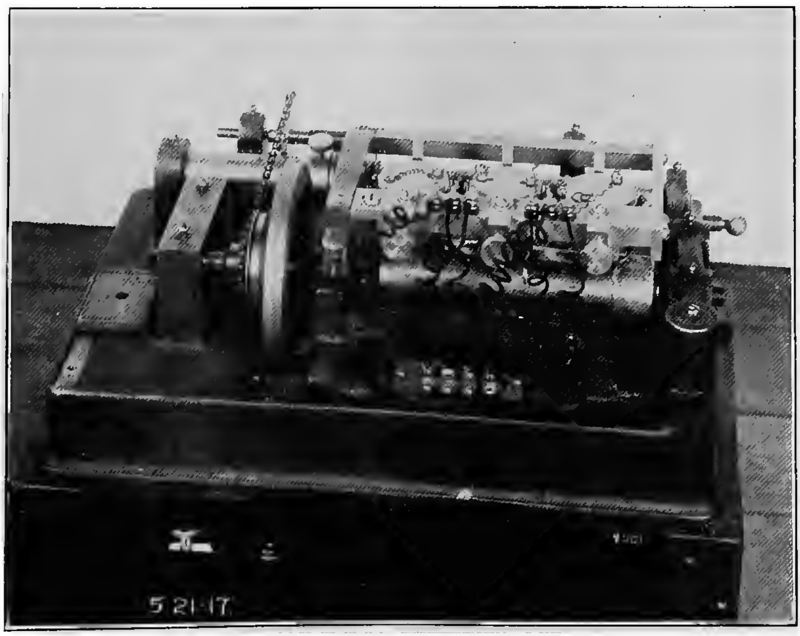


FIG. 2.

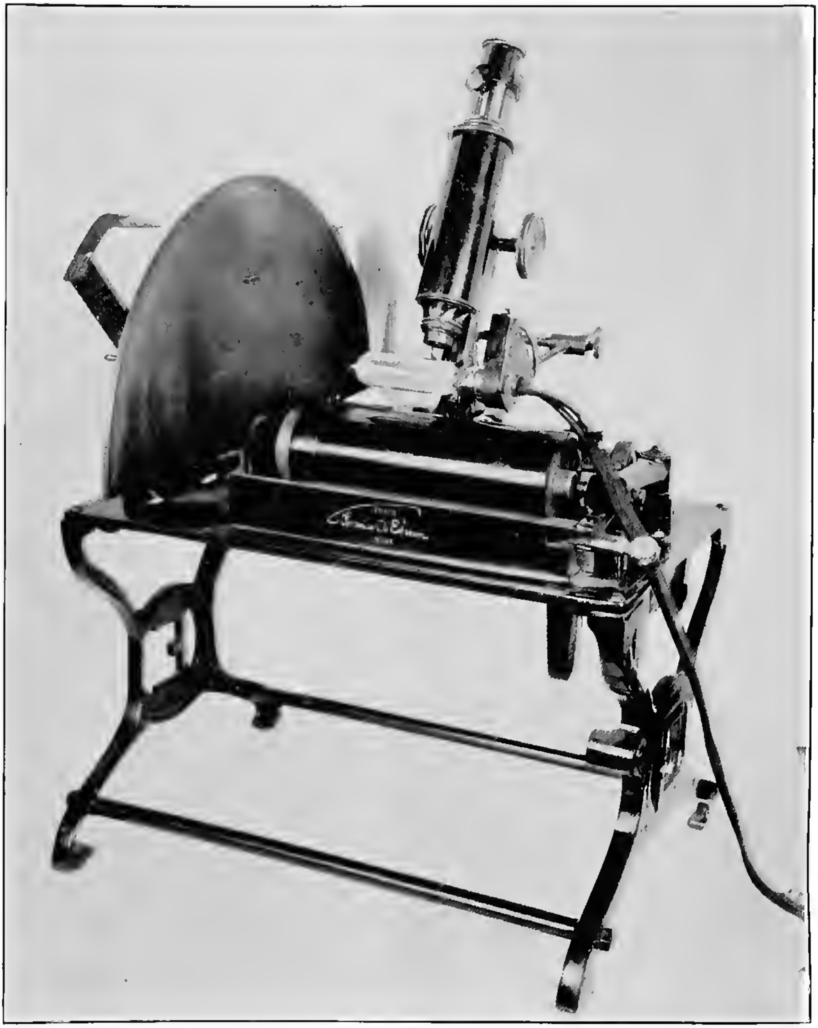
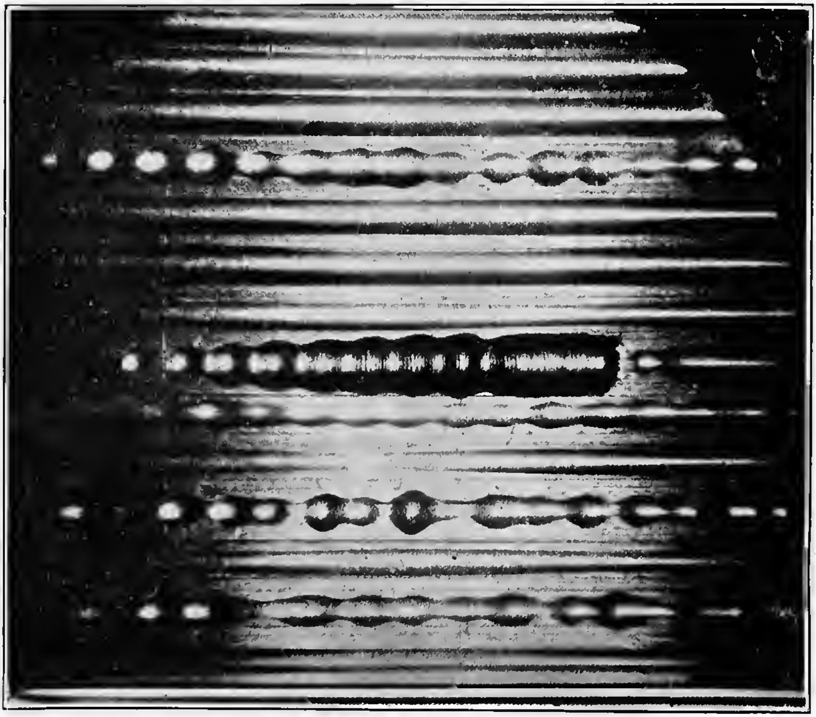


FIG. 3.



GRAPHIC INDICATION OF GUNFIRE.

Sound receiving apparatus consisted of special microphone and horns developed for the particular purpose. Microphones used were a special development of the Edison "lampblack" transmitter, which were used to make the record directly, or by means of vacuum tube amplifiers to control the initial current, if the sound received was not of great enough energy to make a clear reading record.

Sound identifying apparatus consisted of a special reproducing phonograph, provided with an electromagnetic operated marker which was controlled by the observers whenever they heard the gun sound as recognized amongst other sounds that might have been recorded. This instrument was used to closely locate a particular gunshot when there were interfering noises of equal intensity, and it was hard to identify the gun sounds by its graphic outline.

Tests and results.—Mr. Edison's constant endeavor was to keep the length of the base line short, and therefore his efforts were to keep the chance of error as low as possible in all his apparatus.

Actual tests, made with modern guns, showed that under varying weather conditions the position of an unknown sound could be located within 2 per cent, plus or minus, of the measured distance, with a base line not exceeding one-sixth of the range distance. Under favorable conditions some remarkably close results were obtained.

With a base line 1,800 feet long (the longest base line used) the gun has been located over 2½ miles away, within a foot or two of the actual position.

When records had been obtained on a particular type of gun for study, it could usually be identified by a trained observer from guns of other caliber.

Peculiar advantages of the phonograph method of recording.—First. The use of the phonograph for recording the sound permitted of the use of an easy portable machine, of rugged construction, much easier to handle than a delicate galvanometer. Second. Records were available immediately after being made and did not require any further treatment to make them readable. Third. The records, besides being visible, could also be used acoustically, and a double check made in identifying the record of the sound wanted. (It is often much easier to identify a particular sound by the ear than by its graphic outline on the record.)

TELEPHONE SYSTEM ON SHIPS.

Having learned that telephone systems on ships were not very reliable, Mr. Edison devised one that was. He discarded the microphones that were in use and substituted the receiving phone for a transmitter, thus replacing the microphone with an instrument of precision. The signals being weak he amplified with an audion up to a point where the signals could be made so loud as to be painful to the ear. Experiments were continued in the development of an improved earpiece and conditions assuring no difficulty in hearing a conversation irrespective of any amount of noise.

Officers from the Brooklyn Navy Yard visited Mr. Edison's laboratory to make tests.

EXTENSION LADDER FOR SPOTTING TOP.

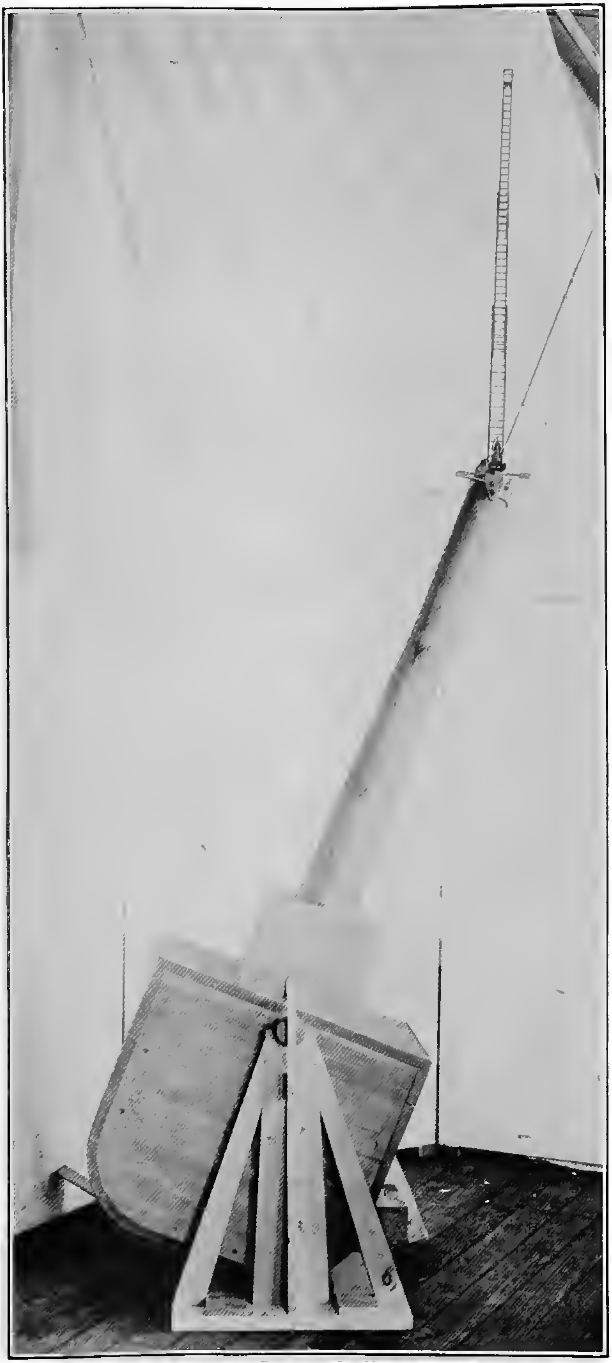
One of the requirements of the Navy Department was for increased facilities of observation on warships. Early in 1917, Mr. Edison called the attention of the department to a newly invented extension ladder, which he suggested could be attached to the observation masts in such a way as to be ready to run up into position at any time in a few minutes. This could give an observer a location 87 feet above the top of the mast, thus increasing the area of observation and would also have the further advantages of being generally above surface fogs and allow for a better angle of observation.

Mr. Edison had a model made which is shown in the photograph. It will be noted that the model shows a conventional cross section of a warship, with mast, on which the extension ladder is mounted. It will also be noted that the extension ladder is arranged so as to be always vertical irrespective of the roll of the ship.

REACTING SHELL.

A problem was given to Mr. Edison by the Army Department. He was told that it was desirable that shrapnel shells should burst about 6 or 8 feet above the ground, a time fuse being used to accomplish this end. Sometimes, he was told, the fuse did not act quickly enough, or not at all, and the shell would fall into the mud. If the fuse acted by exploding there it would fail to do the execution for which it was intended. If the fuse did not act at all the shell was a loss. Mr. Edison was asked if he could devise a form of shell that would overcome this trouble, and he subsequently suggested to officers of the Ordnance Department such a type of shell.

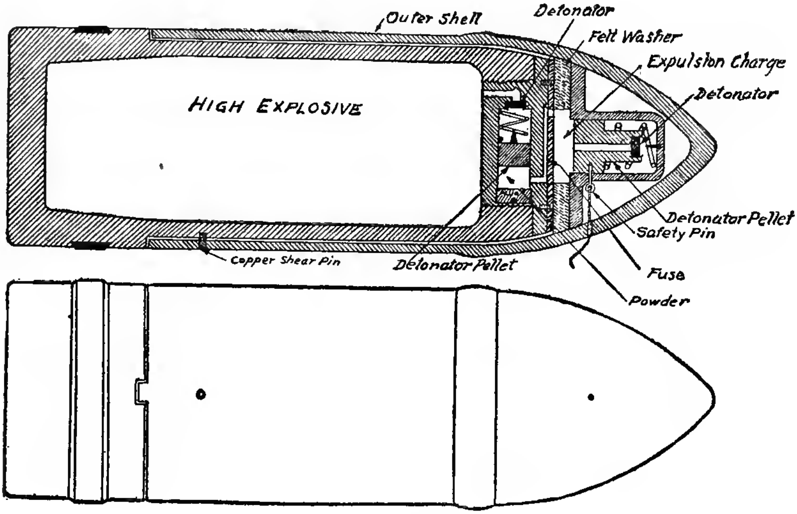
It was a projectile of the regular type with the addition of an additional chamber in its nose containing a small quantity of black powder to be exploded by concussion. If the shell fell into the mud without bursting, the small charge of black powder would be exploded and cause the shell to be thrown up into the air for a few feet, where it would be burst by means of a train of powder leading



SPOTTING TOP.

to the bursting charge. Drawings of this proposed shell were given to ordnance officers.

Mr. Edison was informed that the Germans were using a reacting shell of a similar type toward the end of the war.



NIGHT GLASS.

For several months Mr. Edison maintained a line of experiments on a telescope for making observations at night. He borrowed a glass from the Brooklyn Navy Yard for use in making comparisons, and constructed another one based on preliminary experiments. This glass in practice showed dim outlines where the Navy glass showed nothing.

From the experience gained by this glass Mr. Edison made another which revealed further improvement and resolved dim outlines into details. More extended particulars are as follows:

Theoretically the brightness of the image in a telescope with a given magnifying power is proportional to the area of the object glass.

If the magnifying power is increased for an object glass of given diameter the same light has to be spread over an image of greater area, and the brightness of the image is inversely proportional to that area, or inversely as the square of the magnifying power.

The realization of the full theoretical effect is limited by one being able to discover glass with a perfection of certain definite properties. It is also limited by the size of the pupil of the eye, as the pencil of light emerging from the telescope must be small enough to enter the pupil or part of the light will be wasted.

The specifications regarding definition and color correction, etc., for an astronomical instrument are very exacting, due to the relatively high magnifying powers used, and accuracy of measurement demanded.

For a night glass the first consideration is brightness of the image and excellent defination may be obtained with a glass constructed on proportions far beyond the limits ordinarily set for astronomical instruments.

Brashear made for Mr. Edison an excellent glass of the following specifications:

Object glass: 15½ inches focal length; 4½ inches aperture. Eyepiece: Huygenian, 2 inches equivalent focus; ¾ inch diameter of eye stop.

Pupils dilated by observer wearing dark glasses and holder allowing no stray light to enter eye while not observing. Just before observing eyes are closed, glasses detached, and eyes placed at eyepiece which also is provided with side blinders so no stray light enters eye.

SMUDGING PERISCOPES.

One of the early suggestions made by Mr. Edison was the use of a compound of "straw oil," Cuban asphalt, gilsonite, or Texas asphalted oil for producing a film on the waters in which submarines were operating. The object was to smudge the periscopes and render them useless for purposes of observation.

Having been informed by the Navy Department that compressed air and a stream of gasoline had been used to clear the periscope of any smudging compound, Mr. Edison continued his experiments, and a few weeks later reported another compound of straw oil and a residue from benzol absorbing plants. This compound could not be removed from the periscope by either compressed air or gasoline. In fact, the use of compressed air or gasoline made the smudging more effective.

FREEING RANGE FINDER FROM SPRAY.

An attachment for range-finders for keeping the glass of the finder free from spray was devised by Mr. Edison.

Referring to the photograph, at the aperture of the casing are shown two magazines filled with plates of glass, 25 in number. They are fed across the aperture one after another, by the wheel, which extends to the operator at center of finder. A guarded vent hole prevents guns from breaking glass.

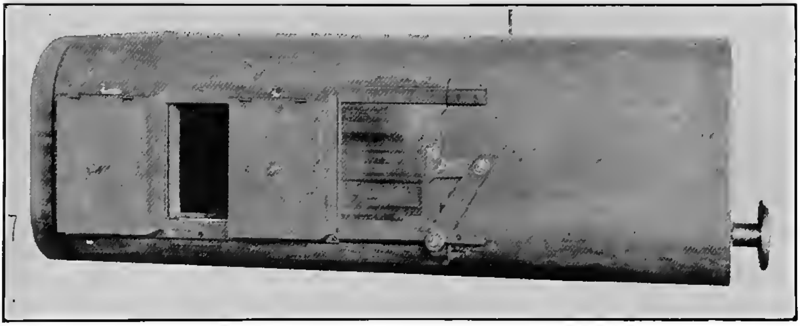
A full size working model was sent to Brooklyn Navy Yard.

PRESERVING SUBMARINE AND OTHER GUNS FROM RUST.

One of the problems submitted to Mr. Edison was to find some method of preserving submarine guns from rust.

He made a large number of experiments and finally found that if extra fine zinc dust is mixed with vaseline and smeared over the gun no rust whatever formed, either in air, or sprayed with sea water, or wholly immersed in fresh or sea water. If only plain vaseline was used the polished steel became badly rusted.

These experiments were conducted for several months in air, also submerged in fresh water and sea water, with entirely successful results.



SPRAY PROTECTOR FOR RANGE FINDER.

CHAPTER XII.

INVENTIVE ACCOMPLISHMENTS OF MEMBERS—Continued.

Mr. Elmer A. Sperry, member of the Naval Consulting Board, who was selected by the American Society of Aeronautic Engineers, was also an inventor of merit and the head of a large company, known as the Sperry Gyroscope Co., engaged in the manufacture of gyroscopes and their installation in connection with other devices. As the Navy was a large user of gyroscopes in torpedoes and in many other connections on shipboard, Mr. Sperry was especially qualified on account of his knowledge of the present state of the developments of the arts concerned in naval warfare to make very valuable contributions in new inventions.

In 1911 and 1912 the Sperry Gyroscope Co. made a start at trying to solve the problem of stabilization of aeroplanes amounting to automatic flight. By the end of 1913 results had been achieved which made those in control of the Sperry Co. justified in representing the United States in a contest at Paris, France, arranged by the war department of the French Government in the spring of 1914 and known as the Aerial Security Contest. A Curtiss flying boat was equipped with the stabilizing apparatus and competed with some 53 other machines which were entered in the contest. These trials were conducted before a committee of 15 of the foremost French scientists, engineers, naval and military men in France, and it was a notable gathering. From time to time the committee also called in other experts to witness the contest.

During the exhibition of the Sperry device it was arranged to have a passenger leave his seat in the aeroplane during the automatic flight of the plane and climb out some distance laterally on the plane, later returning to his seat, in order to demonstrate that the controls automatically took care of this very large upsetting force without the slightest interfering with complete automatic flight. The result of the flights was very successful, so much so that a second series of trials were made of this device before the full committee of judges and other experts, and on July 4, 1914, the Sperry Gyroscope Co. was awarded the grand prix by the judges. The French called this device the automatic pilot.

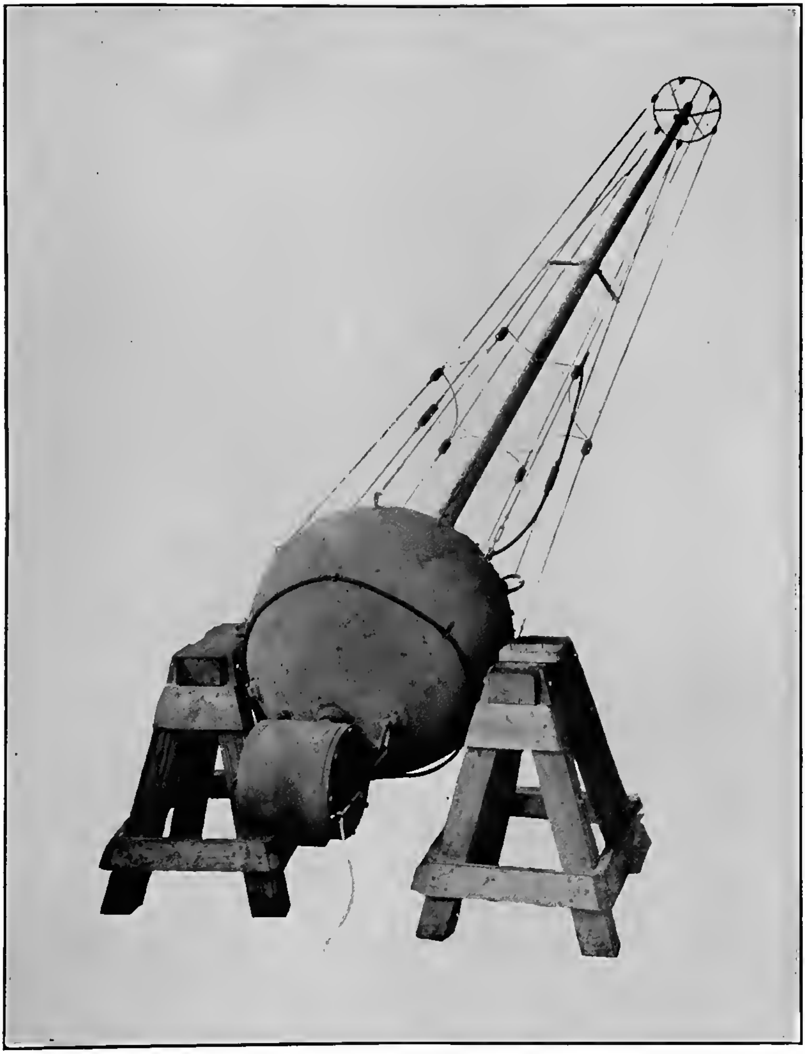
In less than a month from that time Germany had invaded Belgium. Although some sets of apparatus were sent to England and to France, to aid them in the war, which were installed, yet the repeated advances of the Germans and the fact that every available aeroplane was requisitioned the moment it was turned out of the shop resulted in a great delay in the application of the stabilizer to aeroplanes.

Another most interesting and useful contribution by Mr. Sperry was a device known as the "submarine alarm" which sent in an alarm by wireless whenever a submarine passed through a net submerged and anchored, so that when the net was carried away by a submarine, alarm would be given. Following is a brief description of the device and of the experiments made in connection with it:

The submarine alarm consisted of an anchored net with wireless buoys submerged and anchored at the bottom connected with the net at intervals so that when the net was carried away the nearest wireless buoy would be detached from its anchor and rise to the surface. Mounted vertically on the buoy was a tall mast having wireless antennæ. Within the buoy, which was 37 inches in diameter, was a complete wireless outfit with an automatic key, each one giving a different number. A number of these were made and experimented with in lower New York Bay and in the bay off Bath Beach, Brooklyn, and also in Long Island Sound, and they invariably would, when the net was encumbered, come to the surface, float, and at once start out and repeat a number—for instance, 383, 383, 383—at intervals of about once in a minute and a half, for about one hour. The useful radius of the device was 20 to 30 miles. From Bath Beach the number was picked up on the antennæ on top of the Sperry Building, at the Manhattan Bridge Plaza, Brooklyn, 15 miles or so distant.

He made a further contribution to the art of projecting light through water. This involved a great amount of construction and many tests. A clue was obtained from the work of the Prince of Monaco, that the myriads of animalcula in sea water give almost a total reflection of any light beam projected through it. It was determined that water is not like glass, as had been supposed; and that instead of being able to project a beam of light through it, the beam is reflected by the animalcula. An experiment was conducted with a very large light, using 150 amperes, 75 volts, condensed and directed by a 36-inch projector, and with 60,000,000 candlepower in the beam. The beam from the same light has been seen for 62 miles in the air.

This light was placed in the bottom of a steel well, in which were several tons of lead, and in which a lateral window had been provided near the bottom, made from plate glass about 1 inch thick



SUBMARINE ALARM.

APPARATUS FOR TESTING UNDERWATER ILLUMINATION.

and 40 inches in diameter. The well was about 25 feet deep, and was hung by a bale from a crane. Ladders were placed inside the well, and the necessary switchboard, ammeter, voltmeter, and other equipment necessary to operate the light.

The light was first tested in the muddy waters of the New York Navy Yard at a depth of 10 or 15 feet below the surface. It was noticed that there was a total reflection of the light, but this was attributed at that time to the muddy water. It was observed that a sphere of light, 80 feet in diameter, surrounded the window at the bottom of the well. It was brilliantly luminescent. This luminescence was wonderfully brilliant and acted as a fog to obscure vision. Brilliance of luminescence seemed to be about the same at all points in this sphere, even exactly back of the well in the rear of the window through which the light was projecting. After this experiment the clearest ocean water possible was looked for, and an experimental place was selected at a bay at the end of Long Island. The big barge with the heavy steel well dangling at the end of its crane was towed to this point, and additional observations were made with naval officers present. It was also found here that the beam of light could not be projected through the water as had been hoped, and that a globe of luminescence was produced as in the experiments in the New York Navy Yard. The globe of luminescence was visible through this comparatively clear water for possibly a quarter of a mile, and it could be used for the purpose of silhouetting mines, anchors, cables, and other things of this nature against its white background with very great distinctness up to this distance of a quarter of a mile. It is obvious that the presence of animalcula was the cause of this phenomena of total reflection of the light.

He further developed the goniometer, which was an instrument to determine the altitude of an aeroplane when it is the target for people on the ground, and the pretelemeter, which is a device for antiaircraft guns to determine the fuse setter's range and the exact locality of a target in terms of azimuth and elevation, the latter having range deflection. Both of these devices were actually made and put into service.

A searchlight was also developed by him for aeroplane defense, the problem being to throw the beam from the searchlight vertically without harm to the mirror. Up to the time that this was accomplished, 50° was the highest elevation at which it was safe to operate a searchlight.

Mr. Sperry also invented two solutions for the problem of dropping bombs from aeroplanes. The antiaircraft guns frequently drive aeroplanes so high that in dropping bombs from them it is almost impossible to reach a target. It has been humorously said that "they were fortunate if they hit the same county." The device developed was an automatic bomb dropper with a stabilizer equipment for automatically handling the vertical components to a high degree of accuracy. The device was completed and the tests were very successful, bombs being dropped with great exactness. The stabilizer on this device always pointed to the center of the earth, which was a great advantage to the pilot.

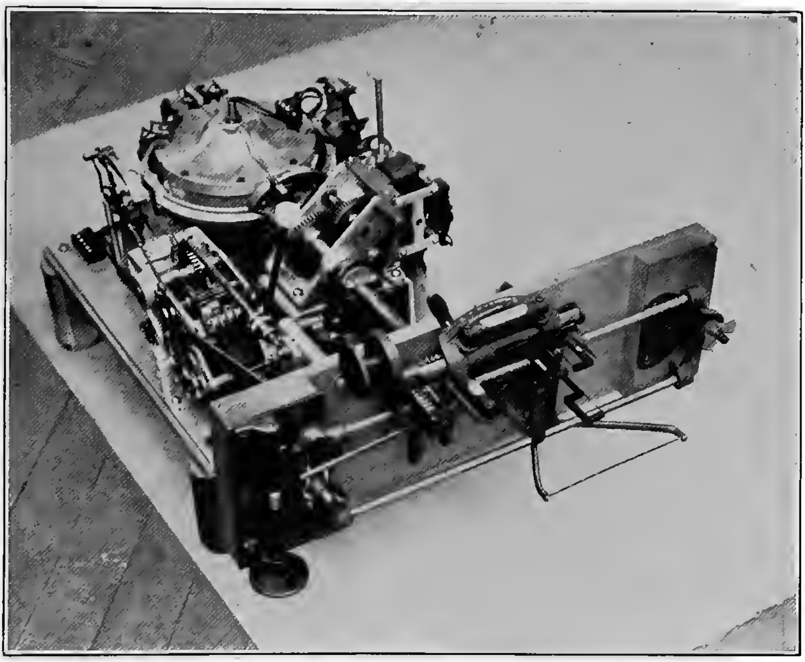
A second solution of the bomb-dropping problem was also developed, incorporating the use of complete wireless control of a bomb as it was being dropped. The bomb was directed by wireless through an antenna attached to the bomb.

These messages when received by the antenna would set in motion a mechanism which automatically adjusted mechanism to direct the flight of the bomb. A big mark was placed on top of the umbrella in the shape of an arrow, which could be seen from the aeroplane. This arrow was painted with aluminum paint, which is actinic, and was clearly visible on the black background of the umbrella. From an aeroplane the descending bomb looked like a big 8-foot ball with a 14-inch mark on it. This allowed the operators to direct it by the methods above mentioned. In solving this problem many difficulties had to be overcome. The mechanism could be and was actually controlled over a distance of 4 miles.

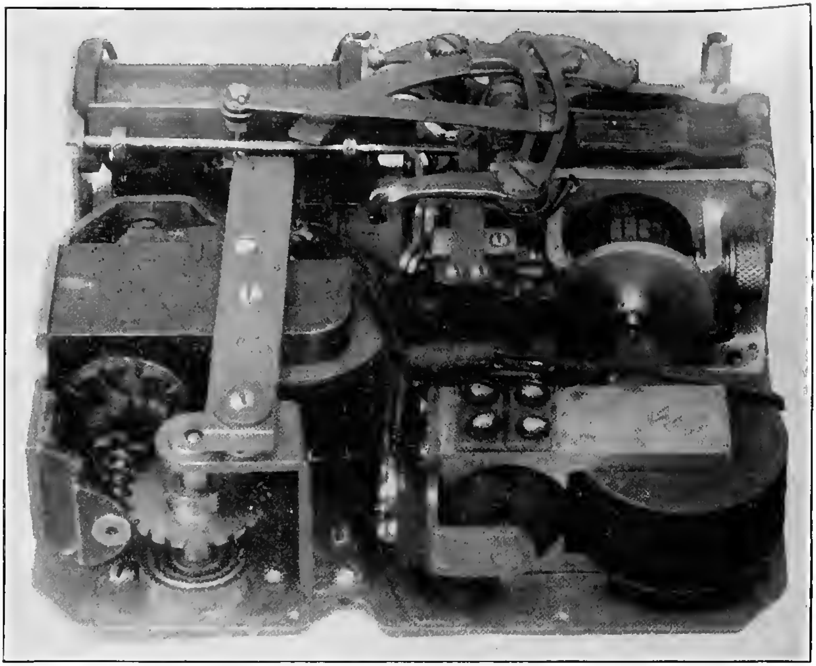
Another device of far-reaching importance was one by means of which the operator of a machine gun on an aeroplane, in combat with another plane, could introduce the element of range, and all the deflections necessary for hits automatically. All aeroplane engagements, up to the close of the war, had been at point-blank range, and the virtue of the device above mentioned was that the range would have been very greatly extended, so that machine-gun fire by the use of this device would have been effective at up to some 1,000 yards by automatic action, and this should have given us a control of the air, because the enemy's fire would not have been effective at the ranges at which we would have been able to score hits.

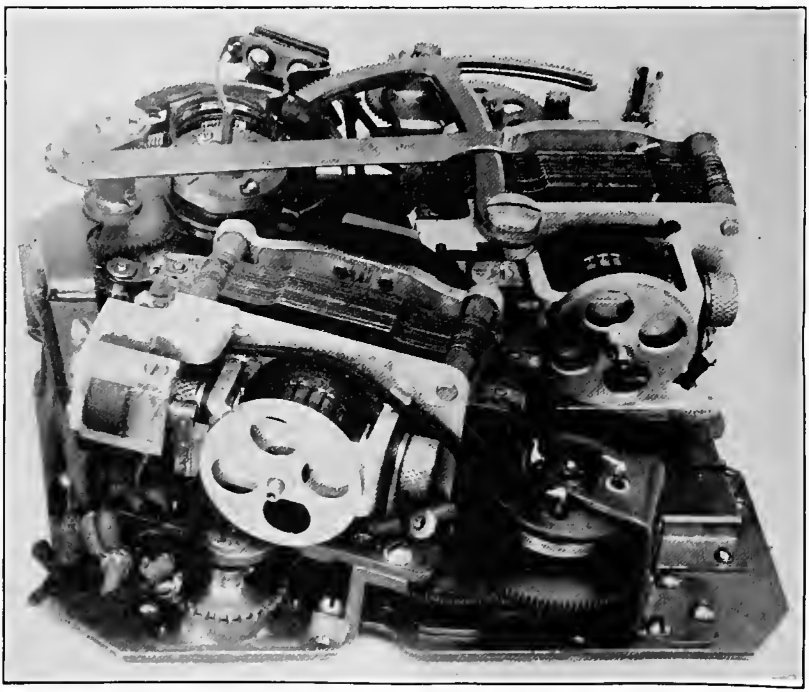
The apparatus was entirely automatic and introduced all of the factors in the aiming of the weapon that the operator of the gun would be obliged to take into consideration, and which it was almost impossible for him to do, owing to the variables involved. The device had been humorously called "the social secretary to the aircraft gun," in that it constantly made appointments for the gun with the distant enemy aircraft.

In the creation of this device there was involved the introduction of all of the mathematical outside ballistics of the projectiles in the terms of angular velocity. An engagement between aeroplanes extends over so brief a period of time that it is impossible for a gunner



BOMB-DROPPING SIGHTING DEVICE.





AUTOMATIC GUN SIGHT CONTROLLING MECHANISM.

to make the requisite calculations for all of his deflection factors, or even probably any of them. This device introduced all of them automatically.

In connection with this work there was developed a very remarkable gun sight designed around two points: First, so that it could be used perfectly by people who do not know how even to shut one eye; second, about a large angular deviation of the eye position; in other words, a large eye field so that if the eye was anywhere within this field the observation was instantaneous as to where the target was located in reference to the cross hairs in the gun sight. The wonderful advantage of this sight is apparent when it is compared with an open sight where three things have to be arranged in an exact alignment to become of the slightest use, the three things being the forward sight, the rear sight, and the eye.

With this device the eye, in any position of the wide-angled eye field, however much the eye might be bobbing around, as is always the case in an aeroplane, an automatic device was placed at the conjugate foci of the sight, bringing the range into the field at all times, so the gunner did not have to take his eye from the sight.

Besides the above, Mr. Sperry and his force made valuable contributions to the art of depth charges. As mentioned above, the depth charge used generally by the United States Navy during the war was made up of contributions by many different scientists, men, and institutions, and Mr. Sperry made his contribution to the development, like many others. The Sperry firing was tried experimentally on the first depth charges constructed in the United States.

He devoted a great deal of attention to the construction and use of submarine nets, and did painstaking work on determinations in regard to steel aeroplane propellers, as well as the detection of hydrogen on submarines. Hydrogen is generated by the Edison storage battery on submarines under certain conditions, and the investigations were undertaken to devise an automatic hydrogen detector which would give an alarm when 2 per cent hydrogen was present in the air. The principle used was the fact that there was an increased heat conductivity in the presence of hydrogen, proportional to the percentage of hydrogen. This was made use of by electrically energizing a small but highly radiant body.

Mr. Hudson Maxim, member of the Naval Consulting Board and delegate from American Aeronautical Society, who is an expert on explosives, naturally found this branch of warfare most interesting to him, and he was therefore made chairman of the Committee on Ordnance and Explosives of the Naval Consulting Board. Besides devoting his time to work on the committee, he experimented on his own behalf, and among other things invented a method for driving torpedoes by means of a self-combustive material, which is called motorite, a compound substantially of the same composition as British cordite, containing about 50 to 70 per cent nitroglycerin and made into a dense colloid by means of guncotton. Mr. Maxim maintained that motorite could be employed safely and successfully instead of compressed air for driving torpedoes, and that by its means several times as much energy for the torpedo's propulsion could be utilized as by the means of compressed air, provided this energy could be controlled.

Motorite is made into long bars several inches in diameter, coated on the outside and forced into steel tubes, and the tubes are screwed into a combustion chamber into which water is admitted and supplied continuously in the right quantity immediately upon the ignition of the motorite, the water being instantly converted into steam by the flame blast of the burning motorite, the combustion of which must be confined entirely to the exposed end of the bar in order that its energy may be controlled.

The armistice was signed before the experiments were completed on this method of driving torpedoes.

Mr. Maxim made contributions to the development of the art of firing mechanisms for contact mines, and invented a device by which a mine could be exploded by slight contact, the firing mechanism of which could not be set off or actuated by the explosion of an adjacent mine.

Many mines were presented to the Government, and each type possessed certain advantages; and the Government combined and utilized the advantages of these different methods in experimental development of mines.

Mr. Maxim also devoted a great deal of time on designs and drawings of a torpedo-proof ship, in which pulverized coal was to be employed in inclosed steel cylinders as the main buffer cargo or protective barrier. In developing this method it was necessary for Mr. Maxim to prove that it was safe to carry pulverized coal in closed steel cylinders on shipboard, it having been asserted that there was danger of spontaneous combustion. His investigations indicated that there is less than a ten-thousandth part of the necessary air contained in coal to burn the coal, so that such an infinitesimal part of the coal is capable of combustion as to render the fact of spontaneous combustion negligible.

In connection with the investigation various methods of production, storage, and burning of pulverized coal as practiced on shore were studied, and it was found that millions of tons of pulverized coal per year were being successfully employed throughout the country; but its main object on shipboard was to lessen the smoke from the stack and consequently to reduce the visibility of vessels as a protective measure against submarine attack.

This work was done under the auspices of the United States Shipping Board. Mr. Maxim received the cooperation of several specialists, who patriotically contributed their service to this work.

The armistice was signed before a ship was constructed, and further progress on the matter was therefore deferred.

With the cooperation of noted steel experts, and particularly Prof. Henry M. Howe, a study was made of gun erosion and of finding ways and means of minimizing it, especially in our big caliber guns. At the time that this investigation was started it was thought that the bore of our 14-inch naval guns suffered such enlargement through erosion that loss of accuracy was very rapid, and that after between 75 and 100 rounds were fired the guns required relining, for which purpose it would have to be taken off the ship and taken to a gun factory, involving much delay and expense.

In investigating this matter analyses were made of the section of a tube of a 4-inch German fieldpiece captured at the front. The thorough consideration of propellants was considered, particularly the use of American pure nitrocellulose smokeless powder which indicated that guns would last much longer by its use without losing the accuaracy. A final conclusion was reached that under the conditions of operation now used the matter of erosion was far less serious than was thought to be the case when the committee began its investigations, and it was found that a 14-inch gun had been fired more than 250 rounds without much loss of accuracy, which would enable the large naval guns to fire twice as much ammunition as the ship ever carries. It was also found that the method of relining large guns and handling them had been so developed that guns could be taken off the ships for relining and could be replaced on the ship in three weeks. As a supply of spare guns is always kept, the ship would not have to wait for its guns to be relined; and that the ship itself, after having been at sea long enough to fire ammunition enough to cause its guns to need relining, would need attention itself as well as time for reloading, so that the ship would not be delayed on its return to sea.

Mr. Frank J. Sprague, member of the Naval Consulting Board, and a delegate from the American Institute of Electrical Engineers, made the following contributions:

Net system.—A system of nets floated by supports consisting of a double line of buoys so connected and proportioned as to slow down the vertical motion of the nets and any bombs attached thereto in rough water, to reduce the strains on all fastenings, and to minimize the visibility of the supports.

This was accomplished by using, in the place of a single main buoy partially submerged, a pair of buoys, one large and one small, connected together vertically, the upper one free and the lower one attached to the net. The large buoy was to be always submerged, 15 or 20 feet under water, and of such size as to provide about 95 per cent of the necessary flotation. The smaller buoy when about half submerged provided the other 5 per cent of flotation.

The wave movement being greatest on the surface, and the violence diminishing rapidly below it, the small buoys only would be individualy tossed up and down, sometimes hardly submerged and with a slack chain, and at other times fully submerged and with a taut chain. As a result the net system and the submerged main buoys would rise and fall slowly, even in a rough sea, with a minimum of strain, impelled by a plus or minus buoyancy varying from nothing to, say, 5 per cent either way.

He did not actually construct any of these nets, but made the model and described the system to the board. This system was also proposed to the Navy Department by others.

Net system with trailing bombs.—In this a system of loosely connected nets, suspended as above described, had at intervals of one two hundred feet pendants secured, to the free ends of which were to be attached bombs with mechanisms primed for explosion but so constructed that they could only be released after the bombs had been trailed a certain distance, the release being affected by a small propeller. The object of this system was to provide means for entangling a submarine with a net section, easily detached with its bombs from the rest of the system by the forward movement of the submarine, the bombs trailing up against the sides of the latter before being exploded. Provision had to be made so that the bombs would not be operated by the tidal current.

A similar idea was independently proposed from outside sources, in which the propeller was made to set and release the firing mechanism, the pendant being attached to a ring, but without means to prevent action by tidal currents.

Air bombs with leaders.—In these, when the bomb was released from an aeroplane, the leader was given a slight advance such that when the bomb was freed the locked position of the firing mechanism was shifted to the connection with the leader, tension on this being maintained by a difference in rates of fall between the leader, which was a stream-line lead plummet, and the bomb, which had means for retarding its fall.

On striking the ground the sudden slacking of the leader connection would release the firing mechanism and permit the bomb to be exploded a short distance above the surface, and hence be more destructive to personnel.

An alternative means for firing was to have the impact of the leader close an electrical circuit which included the detonator of the bomb.

After demonstrating the success of the principle it was found that a similar proposal had been patented in England.

Depth charges.—Of these there were three devised or experimented with. The first was a modification of the return-action shrapnel shell just mentioned; that is, there was a main part containing a charge, detonator, and firing mechanism, and a flotation member connected to it by a cable 15 or 20 feet long, the two parts being normally held together. On dropping overboard they were unlocked, and on striking the water the main charge would go down while the flotation member would be retarded, causing detonation when the cable was pulled taut.

A second type was designed to operate either by mechanical release of a firing mechanism or the closing of electrical circuit, by water admitted through a valve opening which could be set for various depths.

Meanwhile, the English authorities had developed a depth bomb depending upon seepage of water through a variable inlet, and our own Bureau of Ordnance had developed a depth charge which operated by the building up and then release of a ball-lock firing mechanism by the movement of a piston connection to a siphon under hydrostatic pressure, with means for varying the depth at which it would operate.

As an alternative, Mr. Sprague developed and carried through a long series of tests, which are not yet complete, on a depth charge in which both seepage and hydrostatic control was provided, and with means for maintaining the apparatus locked until it was actually in the water. This form seems to present some advantages over the very excellent one in ordinary use.

Delay-action mechanical fuses.—Beginning with an invention originally proposed to him by his son, F. D. Sprague, for an air piston delay-action fuse, there has been, with many variations, three general classes of apparatus developed and tested, which depend upon the inertia of certain parts as influenced by their relation to each other by changes of speeds, both in the air and on impact.

Fuses for under-water submarine attack.—These are for use with flat-nose nonricochet shells, are released (so that they can be armed) by the centrifugal action due to the rifling, armed when they strike the water, and fire either on impact with the submarine under the water or when their rate of retardation has fallen sufficiently.

Fuses for armor-piercing shells.—These are intended for use against thick and thin plates, to be proof against premature detonation, to arm on striking the plate if a sufficiently thick one, or after passing through it, if a very thin one, and to detonate on a thick plate only when coming to rest in the plate or directly after passing through it or within a definite distance after passing through a very thin plate.

There have been two general forms of this fuse. The two conditions are very difficult to meet under the extraordinarily limited test requirements, which, on account of the short distance between gun and plate fixed by the limitations at the Indian Head Proving Ground, do not correspond to actual service conditions. There has been action on both thick and thin plates, sometimes 100 per cent record on the latter, and recently Mr. Sprague devised a machine for recording the variation of friction and for determining the energy of impact, as well as the rate of movement or creep of the detonator in a shell under flight conditions.

Associated with these developments is a new type of fuse, depending upon similar principles, and designed to be used in an air bomb to be launched from a double-control cradle, immune or subject to arming at will. Even when subject to arming, such can take place only on striking the water or the ground, with almost instantaneous action if a hard subject is met, but with a delayed action in water, so as to permit detonation some distance below the surface, or on impact with the shell of a submarine if only a short distance under surface.

All of these types of fuses are still under experimental manufacture and test, although many successful tests have been already made.

Lieut. Charles Messick, a Naval Reserve officer attached to the Naval Consulting Board, demonstrated two forms of vibration communicated from the ordinary two-bladed aeroplane propeller to the aeroplane motor, no means of overcoming which appears to have been previously attempted.

This phenomenon consists, first, of the periodical maxima and minima of the gyroscopic effect of a two-bladed propeller occuring twice in each revolution of the engine shaft when an aeroplane flies other than in a straight line, and second, the vibration occasioned by the unbalanced air thrust when an aeroplane is side slipping or whenever the propeller is moving with relation to the air in other than a straight line. The blade advancing against the cross-air current thrusts harder than the receding blade.

Lieut. Messick's compensating propeller is provided with a universal joint at the hub, where it is attached to the engine shaft, and centrifugal force holds the blades approximately perpendicular to the shaft. The unbalanced air thrust is additionally compensated for by mounting the propeller upon a swivel pin at a leading angle to the length of the blades but perpendicular to the engine shaft, so that when one of the two blades tends to lag, its pitch is increased while the pitch of the advancing blade is decreased automatically. This also balances the variable air thrust against the gyroscopic effect of the propeller.

The Naval Consulting Board built two of these propellers which underwent a successful flying test at the Mineola Flying Field of the United States Army, and demonstrated that an aeroplane thus equipped turns to the right or the left with equal ease, eliminating the tendency to dip when turning in one direction and to nose up when turning in the other direction caused by a rigid propeller. Development of this propeller is being continued by the Army.

Mr. William Le Roy Emmet, member of Naval Consulting Board and delegate from the American Society of Mechanical Engineers, worked on an unsinkable ship, directing his attention toward the accumulation of experimental knowledge in regard to the action of explosives against plates with air spaces and bulkheads, arranged so that the experiment on a small scale with reduced amounts of explosives would give an indication of what type of construction was necessary in order to make ships unsinkable by the incorporation of these principles in the construction of ships.

His experiments were made on eighth size of a section of a side of a ship, and he would take a plate backed by certain structures representing a diminished part of the side of a ship and blow a hole in it with an explosive, using from 1 to 2 pounds of trinitrotoluol (T. N. T.), as compared with 200 or 400. He developed the fact that in this type of construction air spaces and inertia are necessary to get results; in other words, you need something behind the air space that had such an inertia that it will not acquire velocity very readily, He designed a ship of the so-called blister type, the blisters representing those structural changes in the hull of a ship which were necessary to make the ship safe when a torpedo exploded against it.

The building of these special ships was contingent upon there being no other way of defeating the submarine and getting men and cargoes across the ocean. The blisters on a ship with a 60-foot beam would be about 12 feet in thickness, which would be 24 feet, taking into account the blisters on both sides.

Mr. Emmet, an expert on electric drive and turbines and other marine propulsion machinery, was in active charge of that department of the General Electric Co. which was equipping warships and merchant ships with machinery, and therefore was extremely busy with Navy work, and his contributions to the knowledge of the ship-propulsion situation in the Navy and the merchant marine and his special skill in this field was at all times available to the Navy and to the members of the board.

Dr. Miller Reese Hutchison, who became a member of the board by special appointment of the Secretary of the Navy, had been chief engineer to and personal representative of Mr. Thomas A. Edison for a number of years.

In July, 1916, he designed and constructed for the Russian Government, before fixed-position warfare had been done away with and the Russian Government had collapsed, a complete electrical unit for the electrical illumination of "No Man's Land" from the front-line trenches. This unit consisted of:

(*a*) Five 650,000-candlepower searchlights, having no dispersion of the beam in the vertical plane, mounted upon a light wooden pole having ferrule which articulated with an iron pipe driven into the ground. The entire searchlight, mounting and pole, weighed only 30 pounds. Quickly operative from the ground.

(*b*) Eight powerful but very lightweight storage batteries to furnish power for the lights.

(*c*) A two-wheeled cart for the conveyance of the searchlights and batteries, with complete facilities for charging the storage batteries.

This equipment was tested by commissions from Russia, France, England, and officers from the United States Army and Navy, and they seemed to be pleased with the results.

In 1917 Dr. Hutchison received an old gun for experimental work from the Bureau of Ordnance, United States Navy, for the purpose of conducting experiments to demonstrate the practicability of relining guns that are taken in from field of battle, or from their position on shipboard. The scheme consisted of a method for heating by an electric current the outer part of the barrel of the gun, so that the inner tube might be withdrawn. The system consists of the following:

(*a*) To the outer periphery of the gun, for the entire length, is applied a series of coils properly insulated.

(*b*) Alternating current, of low frequency, is supplied thereto.

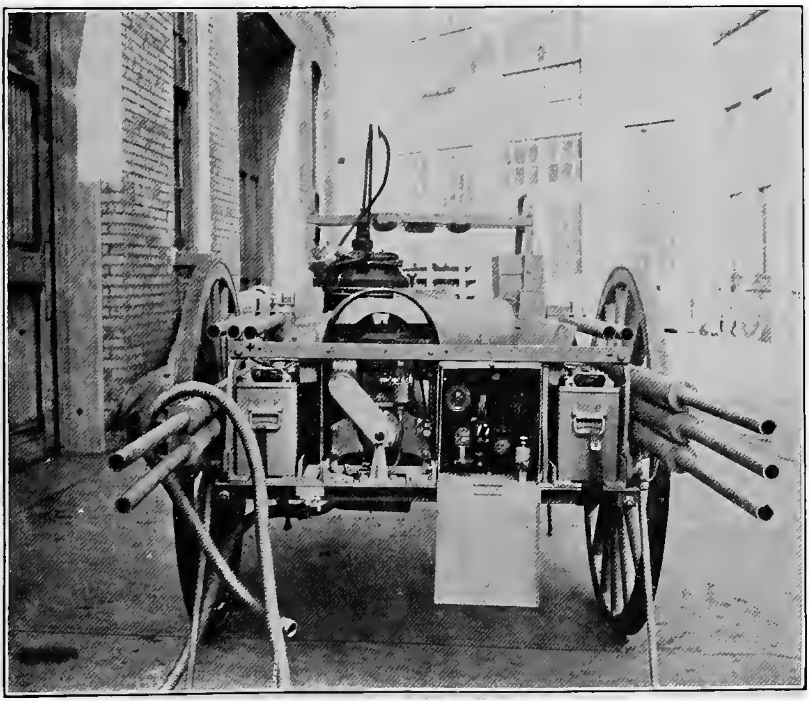
(*c*) The gun becomes a closed circuited secondary of a transformer and within a short time the metal is heated by induction and hysteresis.

(*d*) When hot enough the inner tube or liner is filled with water, shrinks away from the outer tube, and may be readily removed.

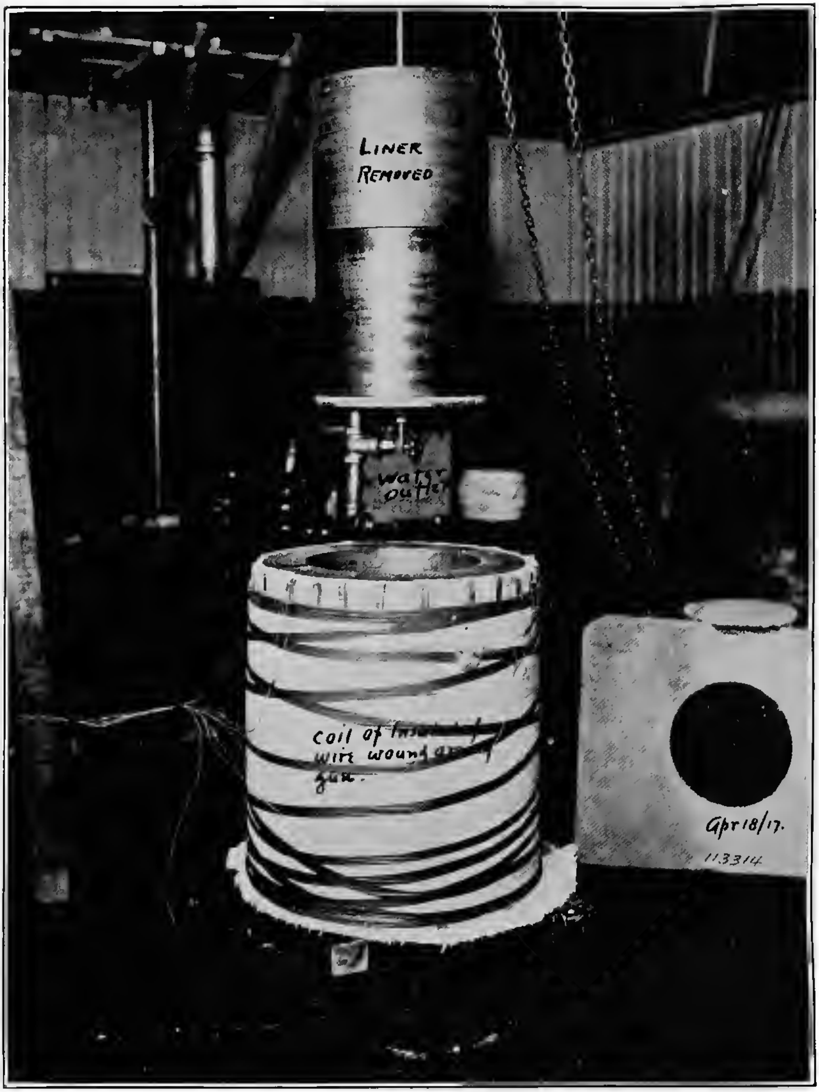
(*e*) A new liner, previously rifled and ready for application, is inserted, the current turned off successive coils, beginning at the breech, and the outer tube is thereby shrunk on.

The Naval Consulting Board recommended this device for use of the United States Navy. The armistice was declared before this could be introduced into practice.

PORTABLE ELEVATED SEARCHLIGHT.



SEARCHLIGHT CARRIER.



ELECTRICAL HEATER OF GUN TUBES FOR REMOVAL OF LINER.

Dr. Hutchison also worked on and designed and constructed a dynamo for light mobile units, but orders came from the American Expeditionary Forces that no electrical lighting equipment should be supplied on trucks shipped overseas.

He worked on a headlight for automobiles which had no telltale dispersion of the beam of light, which was amber colored, and was designed to enable trucks to carry lights on tree-shaded and dark roads of France without attracting the attention of the enemy.

A listening-in device was designed by him in order to enable intelligence officers to listen in on conversations on the telephone.

He also worked on the taking of photographs of projectiles in flight, for the Bureau of Ordnance, United States Navy, with a special camera, which successfully photographed 14-inch shells when leaving and after leaving the nozzle of a gun with a velocity of 2,750 feet per second. Results of the photographs were very interesting and instructive.

As a committee of one, he was appointed by Mr. Hudson Maxim, chairman of the Committee on Ordnance and Explosives of the Naval Consulting Board, to carry through certain experiments on an extension fuse for detonating a shell before it can bury itself and waste energy in cratering. The idea was originally submitted by Maj. G. O. Watts, of the British Army, and Dr. Hutchison carried through his work in cooperation with Lieut. Ralph Coxhead, United States Army, who was assigned to duty with the Naval Consulting Board and who devoted practically all his time and attention to the extension-fuse idea. Lieut. Coxhead was assisted by Mr. Leonard Kebler, of Bronxville, N. Y., who volunteered his services in this connection.

As a result of the combined efforts of these men a very promising construction was evolved. At the time of the armistice some of these fuses were made up for practical tests at the front. The tests of this fuse at the Aberdeen Proving Grounds disclosed the fact that a 6-inch shell so equipped detonates far enough above the soft ground to make a very small crater, with result in increased danger area from fragments.

Results of this work indicated that the extension fuse would no doubt be valuable for many purposes. Its use for barrage work, however, would be limited, owing to the somewhat erratic exterior ballistics of the shell so equipped and the danger to our own forces therefrom when used in barrages.

He also worked on the question of methods of communication between the observer and pilot of an aeroplane and constructed some special transmitters, which were of a better quality than the standard transmitter but not quite so distinct. They were therefore not adopted.

In July, 1918, Dr. Hutchison submitted to the Medical Department of the United States Army a model of a new special surgical needle, in which the gut or silk led out of the end of a needle through a hole provided for the purpose, in order to obviate the disadvantage of the ordinary surgical needles, in which the gut or silk is threaded through the needle as in the ordinary cambric needle apparatus.

Dr. Hutchison also investigated and prepared a detailed report on the burning of anthracite coal on merchant vessels at the request of President Wilson. This work resulted in the development of a scheme of firing this coal so that it could be readily used on merchant vessels.

Dr. Peter Cooper Hewitt, of the Naval Consulting Board and delegate from the Inventors' Guild, did some very extensive work on the helicopter, and following is a description of it:

The fundamental object of the helicopter is to obtain a lift more than equal to the entire weight of the machine; that is, to obtain an upward pull by means of dynamic action of propellers greater than the total weight of the machine, including motors, fuel, and load, so that the machine will be forced upward and lifted into the air.

The helicopter that he designed, hereafter called helicopter No. 1, has propellers of large diameter adapted to act upon a large mass of air, and the blades are designed to approximate the action of aeroplane wings to obtain the advantage of their lift.

In earlier considerations of this problem it was thought possible to accomplish ascension by the simple reaction resulting from the downward acceleration of the mass of air acted upon by the propeller.

The laws relating to reaction due to acceleration of a fluid (air) are perfectly understood and exact calculation can be made for obtaining the required lift for any specific weight of machine. The conditions being that the dynamic reaction in pounds obtained per horsepower multiplied by the available horsepower must exceed the total weight of the machine and motor in order that the machine may rise from the ground.

The laws of momentum and consideration of resulting distribution of energy due to the action of the propeller must be taken into account. This requires a careful determination of the size of the propeller used, and it must be so chosen that the weight of air acted upon per second and the velocity imparted to the air will give the desired thrust or pull, lift per horsepower being proportional to the size.

It appears that up to the present it has been considered very important to have a very light machine and very light motors. This is not necessary, as the lift obtainable with a motor—that is, the lift per horsepower—is proportional to the quantity of air handled or proportional to the size of the propeller used. The propellers used before Dr. Hewitt's experiments appeared to him to be too small in diameter for the horsepower designed for their operation. Recent dynamic research has brought forward new and most important discoveries whereby great advantages have been obtained by the form of lifting surfaces used. The investigation of supporting surfaces for aeroplanes has developed planes where the lift obtained from the upper and lower surfaces of the plane are not the same, that obtained from the upper surface being much greater than that obtained from the lower surface. The resulting total lift is much greater per horsepower than was formerly considered as possible by simple dynamic action.

In order to avail of the advantages of these discoveries and apply them in a helicopter it is necessary to know how the conditions of lift are affected when a plane is rotated as the blade of a propeller and when the plane is acting as a propeller blade to obtain results as advantageous as those obtained by an aeroplane wing. It is also very important to know how these results are modified and influenced by the diameter of the propeller, the size of the propeller blade, the speed of revolution of the propeller, and the relation of the size of the propeller to the horsepower with which it is driven.

Helicopter No. 1 was designed so that it might be operated to furnish practical data relative to these various problems and enable their solution, and particularly for obtaining data relative to the relation of diameter to lift per horsepower for the horsepower used. It was designed to be operated with 200 horsepower at 100 revolutions and sustain a lift of 4,000 pounds and withstand the unequal strains due to buffeting of the air. It was built entirely of steel, except the ribs of the propeller blades and the blade covering, which are of sheet aluminum. The design, size, material of construction, and strength were such as to serve as a guide for estimating the necessary weight of the whole and the various parts in future designs and suggest desirable modification of design.

The experimental data furnished by tests of helicopter No. 1 show that the aeroplane-wing lifts are obtained, and that the lift per horsepower for a given diameter is in excess of that formerly thought possible to be obtained by simple dynamic reaction.

Although for various reasons it has as yet only been operated with about six-tenths of the horsepower for which it was designed, it has given a lift more than its own weight and the weight of standard motors of this horsepower and a surplus of more than the weight of a man and fuel. (See capitulation of tests.)

Helicopter No. 1 consisted of two propellers, one above the other, each 51 feet in diameter, one being right hand, the other left, rotating in opposite directions in operation. The power-transmission shafts are concentric and driven by two motors, whereby the torque is transmitted without load on the bearings or working stress transmitted through the frame.

In operation there is but little, if any, tendency of the motive power support to rotate, balance of the propeller torque being more easily obtained than was expected.

The propellers are designed so that the center of support of the blade is forward of the center of lift in order to promote smooth action and avoid chattering (the practical working is perfect). This gives a small torsional moment to the tube which acts as the compression member or arm of the propeller which is held at the hub. This tube runs through the blades to which they are fastened. The operation of the propellers is most satisfactory.

The shape of the propeller blade is that of Eiffel wing No. 63. This wing was selected because of the exhaustive treatment of it in "Nouvelles Recherches sur la Resistance de L'Air et L'Aviation, Faites au Laboratoire D'Anteul," which was thought might prove useful in case of eccentricities being observed during the tests and would enable modification to be intelligently made. Wing No. 63 has only 75 per cent the efficiency of wing No. 32, which Dr. Hewitt hoped to substitute for it and obtain 25 per cent advantage in lift.

In a test the blade, being set at an angle of 12° at the circumference, gave in operation at various speeds a lift fairly accurately corresponding to the lift such a blade should give if acting as the wing of an aeroplane set at about 6°, demonstrating the faithfulness of the action of the blade and also giving very valuable data for consideration respecting its action in this connection and suggesting the great importance of further investigation. This apparent angular loss of power will become, no doubt, useful power for movement when the machine is not stationary, and during the tests a side wind caused the machine to develop great additional lift.

Helicopter No. 1 weighs about 1,500 pounds and has an excess of weight of more than 300 pounds which is capable of being removed. This excess weight is due to not being able to obtain standard tubing of suitable size at the time of construction. Standard Hess-Bright ball bearings are used throughout and are entirely out of proportion to the work required of them. Suitable gear were not obtainable, so a makeshift set was installed to save time. Suitable gears would have been easily obtained in ordinary times.

The machine set up for testing is mounted on a platform together with its motors, which stand on scales, the platform resting on a small ball-thrust bearing which is between it and the scales so that the machine is free to rotate. This enables measuring any inequality of torque of the propellers and any tendency of the motors to rotate. The balance is so perfect that the whole may be turned with one finger.

The total weight of machine and motors, before starting the tests, is taken, being about 9,000 pounds, which is read on a dial of the scales graduated to 10 pounds, and can be read accurately to 5 pounds. During the test the original weight is reduced by the amount of the lift obtained, which the scales continually registers and is shown by the dial. As more power is used and the lift becomes greater, the scales register less weight. The machine during the tests is operated by calibrated electric motors for accurately obtaining momentary power reading.

The following results of tests explain themselves:

Approximate summary of helicopter No. 1 operated with gasoline motors.

		Pounds.
Weight of helicopter No. 1		1,500
Two Gnome motors, weight 96 kilos each		423
Addition to frame		100
Total weight		2,023
Lift (test No. 35) with 126 horsepower		2,550
Excess lift (for fuel tank and man)		477
Being excess lift per horsepower		3.77
Removing 300 pounds excess weight from machine weight		1,200
Substituting wing No. 32 for wing No. 63, No. 63 being only 75 per cent efficiency of wing No. 32, modified machine lift		3,090
Machine weight	1,200	
Motors	423	
Addition to frame	100	
		1,723
Excess lift		1,367
Lift per horsepower in excess of weight		10.8

Much better results would have been obtained with the use of more horsepower.

The peripheral speed of the propeller blades (at 2,550 pounds lift and 70 revolutions per minute) is 187 feet per second or 11,220 per minute, and the mean average blade speed (at 20 foot radius) 146.5 feet per second or 8,800 feet per minute, which should give a possible horizontal movement of about 4,400 feet per minute, or, say, 40 to 50 miles per hour. By using smaller blades or smaller blade angle higher peripheral speeds may be used and higher lateral speed obtained.

Substituting wing No. 32 for wing No. 63, greater peripheral speeds can be used, which, under substantially the same conditions, will give greater speed of lateral flight.

One important thing that was demonstrated was that propellers of large diameter could be operated successfully. The propellers used were 51 feet in diameter, and no objection was found to operating propellers 100 feet in diameter. The propellers were probably lighter in construction in proportion to their size than any other propellers ever built, and were amply strong to lift 4,000 pounds. There are certain reasons why these propellers worked successfully and why other propellers would not. The reason is that the center of support is forward of the center of the lift, so that the propeller has no tendency to chatter. It has a uniform drag.

The data developed by Mr. Hewitt in regard to the helicopter placed us in the possession of information which would have been extremely useful in the event of a helicopter appearing over the German lines, as it would have given us the necessary information to proceed at once to manufacture helicopters. We had nearly everything except the data necessary to their construction, and this was obtained by these tests, although the machine worked with by Mr. Hewitt never left its scales.

Mr. Hewitt made contributions to many arts before the war, particularly in regard to vacuum tubes. One of the essential features of the wireless telephone, which was one of the greatest inventions made during the war, incorporated tubes which generated the currents for operating these devices. As advances in one art react on all other arts, it is very difficult to make valuations of contributions to the arts which are made by men like Mr. Peter Cooper Hewitt.

He also did a great deal of development work upon the question of a rotary motor to be operated by gasoline.

Mr. David W. Brunton, a member of the Naval Consulting Board, representing the War Committee of Technical Societies, was fortunate enough to have four of his instruments accepted for use in the war. These were the pocket transit, combination alidade and protractor, fire-control instrument, and instrument for locating snipers.

The pocket transit (figs. 1 and 2) was originally designed for use in underground surveying and has come into almost universal use for both surface and underground work by mining engineers all over the world. It has also been adopted by the United States Geological Survey for use in geological and topographic work, and is used in large numbers by the Forest Service and by civil and hydraulic engineers in making reconnaissance surveys.

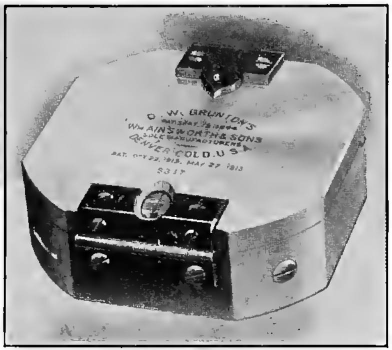


FIG. 1.—POCKET TRANSIT.

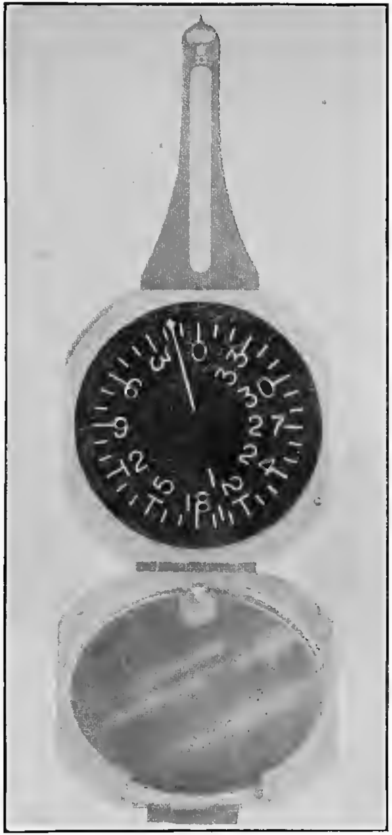


FIG. 2.

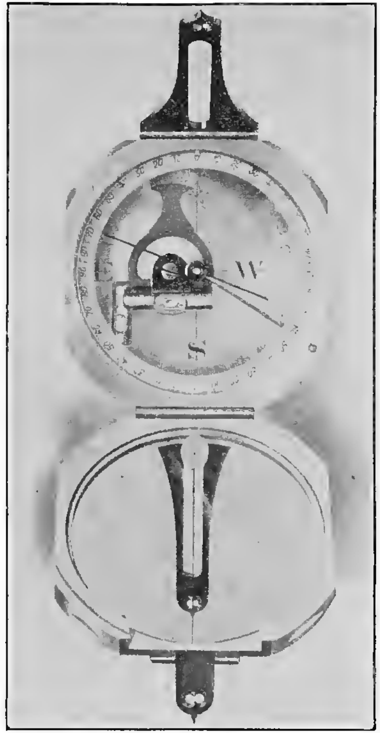


FIG. 3.

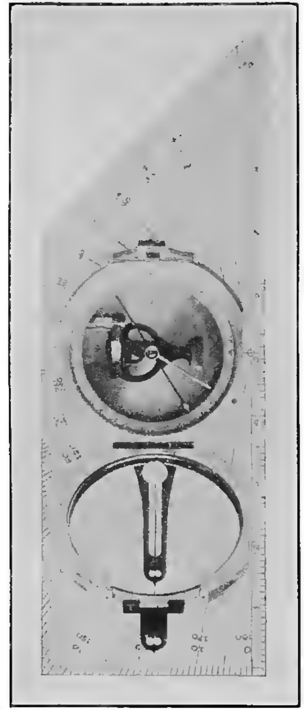


FIG. 4.

When war was declared the Engineer officers going to the front naturally took their instruments with them, and their compactness, coupled with their extreme accuracy and the rapidity with which readings could be obtained, brought them into general favor with Army officers.

On the instrument (fig. 3) as constructed for military use the under side of the cover glass carries a graduated circle on which the divisions and figures are made with a radioactive material which has permanent luminosity and permits the use of the instrument for night reconnaissance in the immediate vicinity of the enemy. This circle is smaller than the metallic graduated circle underneath and does not in any way interfere with its use in daylight. The upper side of the needle is also made luminous with the same material.

Many of the Engineer officers, from long practice, were extraordinarily expert in the use of this instrument, and some very unusual work was performed with it at the front.

The most spectacular of these exploits was the blowing up of the Austrian fort on the summit of the Col di Lana by Capt. Gelasia Caetani, of the Italian Army. With a radium illuminated Brunton pocket transit the captain made a survey through the Austrian lines at night to obtain the exact location of the fort, after which he drove a long tunnel and an upraise, from the end of which the fort and its garrison were blown to pieces. When the work was done, out of curiosity to see how correct his midnight survey had been, the captain made an examination and found he had not missed the center of the fort more than 3 feet.

The "alidade protractor" is an attachment for the pocket transit which enables it to be used in plane-table surveys, where it bears the same relation to the large telescopic alidade that the pocket transit does to the theodolite.

The device (fig. 4) consists of a celluloid protractor and scale with a central opening which fits closely around the guard ring of the pocket transit, which is held in alignment with the sights by a small stud.

Sighting is performed in the same manner as in reading courses, i. e., by viewing the object in the mirrored lid by reflected light, with the center line bisecting the opening in the front sight. This enables the operator to work in a comfortable attitude without changing his position from sighting to line drawing and vice versa, which, of course, conduces greatly to both speed and accuracy.

The graduations and figures in the alidade attachment are clear and distinct, and, by a new process, are placed on the inside of the celluloid, where they are completely protected from wear.

The thickness of the alidade protractor is only 0.06 of an inch, and it can be very conveniently carried in a note or sketch book.

Three orders were received from the Government for this device, totaling in all 7,905 alidades, but only the first order for 2,910 was completed before the armistice was signed.

BRUNTON'S FIRE-CONTROL INSTRUMENT.

This instrument is an adaptation from the pocket transit and is designed principally for use with heavy nonportable machine guns, but may also be used for surveying. It differs considerably from the transit in design, one of the principal points of difference being the graduated circle, which is divided according to the French system into 6,400 mils instead of 360 degrees.

The Government ordered 1,500 of these instruments, all of which were promptly manufactured and accepted.

INSTRUMENT FOR LOCATING SNIPERS.

In modern warfare, when trenches or other cover are used for defensive purposes, sharpshooters, or "snipers," as they are sometimes called, are stationed at intervals along the line of front for the purpose of "picking off" any enemy who shows his head above the parapet of his trench. When a man is hit by a sniper, it is very difficult, and in fact well nigh impossible, to locate the sniper, because no one knows, except in a general way, from what direction the bullet came.

The object of this invention is to provide an instrument for locating the positions of enemy snipers so that they may be dislodged and thus prevented from disabling or killing men who must necessarily at times expose themselves for taking observations and for other purposes.

The invention consists of an instrument mounted on an extension tripod, carrying on an adjustable head which can be elevated and lowered by a rack-and-pinion movement through a vertical range of 30 inches. This head carries a papier-mâché model of a soldier's face and cap, behind which are placed, 14 inches apart, a pair of thin diaphragms of soft wood veneer, a registering adjustable plate, and a periscopic telescope with a 12-inch drop.

When in use the instrument is set up in a trench with the adjustable tripod legs clamped to such a length as will allow the decoy head, when fully elevated, to show above the parapet. When in this position, in order to attract attention and draw the enemy's fire, the decoy head may be lowered and raised just as if an officer was engaged in taking observations.

When the enemy sniper registers a hit, the head is lowered by the rack-and-pinion control tube, after which the bullet holes in the spaced-apart diaphragms are centered by a simple device and the powerful periscopic telescope adjusted so that its line of collimation is exactly in the path of the bullet. As the instrument head in its lowered position is 2 feet below the parapet, these operations are carried on in comfort and safety, thus leaving no excuse for careless work or hurried adjustments. When the instrument is again raised, the position of the sniper, or at least his nest, is plainly visible in

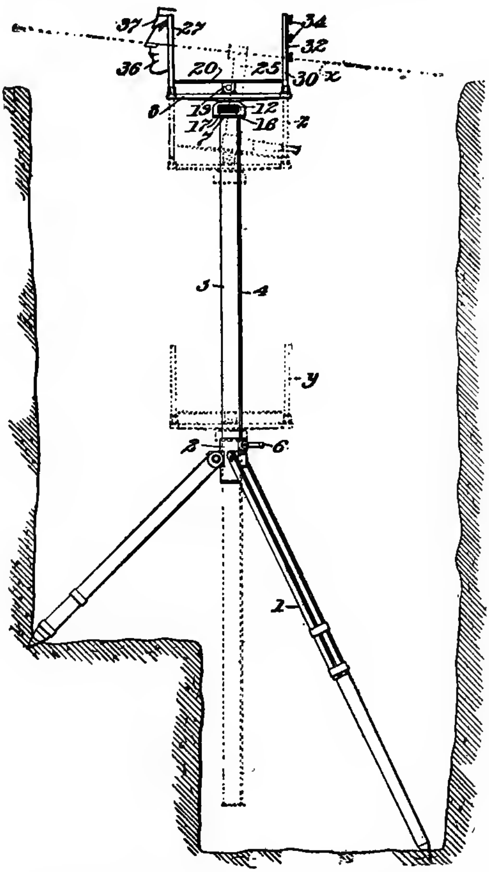


FIG. 5.—Instrument for locating snipers set up in trench.

the cross hairs of the telescope, after which his days of usefulness are soon ended.

As another indication of the wide field of usefulness of the Naval Consulting Board, it should be mentioned that Dr. Leo H. Baekeland, one of its members, early in the history of the board became impressed with the necessity of making the United States independent of Chile for its supply of nitrates, by the erection of a synthetic nitric acid plant. On March 8, 1916, a unanimous resolution of the Naval Consulting Board was transmitted to the Secretary of the Navy to this effect. Thereafter Dr. Baekeland endeavored to educate Congress, the Navy and the Army, and the people of the country to the urgency of this problem by publishing articles in magazines, technical and scientific journals, as well as by public lectures. He appeared on this subject before the Senate committee, and helped to prepare the first bill, which on its final passage provided an appropriation of $20,000,000, for the starting of the first synthetic nitric acid plant in the United States.

He was thereafter appointed a member of the first Nitrate Supply Committee, which presented the first definite recommendations as to what processes were most available. His associates on this committee were A. A. Noyes, Gano Dunn, George Ellery Hale, C. H. Herty, W. K. Lewis, M. I. Pupin, T. W. Richards, Elihu Thomson, and W. R. Whitney.

He was appointed on the second Nitrate Supply Committee organized at the request of President Wilson, which held its first meeting on May 11, 1917, the other members of the committee being Gen. William Crozier, Rear Admiral Ralph Earle, representatives of the Department of Agriculture, Bureau of Mines, Bureau of Standards, besides Prof. Chas. H. Herty, Prof. A. A. Noyes, and Gano Dunn.

Early in 1917 he undertook, at the request of the Navy Department, the then rather new problem of smoke-screen bombs, which work was later taken up and continued by the Bureau of Mines.

He initiated the first steps for supplying aeroplanes with cyclohexane as an improved fuel for high altitudes, and organized the first committee for determining the qualities of a standardized fuel for aviation, which could be adapted to the needs of all the Allies and which could be supplied in sufficient quantity.

He cooperated with many other committees and other war boards on numerous war problems involving chemical questions.

Dr. A. G. Webster took up the question of emitting a musical sound under water, and at the request of a member of the staff at New London, where they were working on listening devices, he invented an apparatus which he exhibited at the American Physical Society and the National Academy of Sciences. It was a mechanical imitation of the human lips which, if applied to any brass instrument like a bugle or other horn, played it automatically by compressed air in air; or, if played under water or furnished with water under pressure, played it there.

Through private means he established a ballistic laboratory in which valuable results were obtained, chief of which was the invention of a gauge for measuring the pressure in a gun as a function of the time, and an instrument for drawing trajectories of all sorts.

OPTICAL GLASS.

The optical industry in this country before the war was in the hands of a few firms. Several of these were under German influence, and one firm was directly affiliated with the Carl Zeiss works of Jena, Germany. The workmen were largely Germans or German origin; the kinds and design of apparatus produced were for the most part essentially European in character. Optical glass was procured entirely from abroad and chiefly from Germany.

It was easier and cheaper for manufacturers to order glass from abroad than to develop its manufacture in this country. Educational and research institutions obtained a large part of their equipment from Germany and offered no special inducement for American manufacturers to provide such apparatus.

With our entrance in the war the European sources of supply for optical glass and optical instruments were cut off abruptly and we were brought face to face with the problem of furnishing these items to the Army and Navy for use in the field. An immense amount of optical glass was needed by almost every department of the Army and Navy for fire-control instruments of different kinds, telescopes, field glasses, and various instruments, including periscopes, depression position finders, azimuth instruments, telescopic musket sights, etc.

The largest order for fire-control equipment which our Army had ever placed prior to 1917 amounted to $1,202,000. The total orders placed for such instruments by the Ordnance Department during the 19 months of war exceeded $50,000,000, while the total orders for fire-control apparatus placed by the Army and Navy exceeded $100,000,000.

In 1915, after the European war broke out, the situation in regard to optical glass was appreciated by various optical concerns in the country, who experimented in a limited way in order to rectify it, but very little progress was made. The United States Bureau of Standards at Pittsburgh, Pa., had done some work, but in 1917 Dr. Leo H. Baekeland, a member of the Naval Consulting Board and chairman of the Committee on Optical Glass of the board, who was following the optical-glass situation very carefully, came to the conclusion that energetic steps must be taken to meet the situation. He took this matter up with his colleague on the Naval Consulting Board, Dr. R. S. Woodward, president of the Carnegie Institution in Washington, D. C., and acquainted him with the serious nature of the situation.

Dr. Woodward very patriotically offered the facilities of the geophysical laboratory of the Carnegie Institution to solve this problem. This laboratory had been engaged for many years in the study of solutions, such as that of optical glass at high temperatures, and had a corps of scientists trained along lines essential to the successful production of optical glass. It was the only organization in the country with a personnel adequate and competent to undertake a manufacturing problem of this character and magnitude. Accordingly, in April, 1917, a group of scientists was placed at the Bausch & Lomb Optical Co. and given virtual charge of the plant, and its men were assigned to the different factory operations and made responsible for them.

The first step that was taken by these scientists was to make an analysis of optical glass from Germany, and to find out its composition. Results of this analysis enabled these men to make formulæ, and they then went into the factories and tackled the problem of production. They had some 20 men in the various factories, and these men developed methods of making glass forms, stirring the glass when melting, and annealing it. They were also obliged to go into the question of making the proper kinds of crucibles in which to melt the glass.

Up to this time there were only two men in the United States who were at all expert in making optical glass. There was one man at the Bausch & Lomb Co. who knew something about the art, but his knowledge was more that of an operator than that of a scientist, and he had no knowledge of the stirring or mixing or the purities of the materials, etc. These factors were worked out by the staff of the Carnegie Institution. After the optical glass had been produced, it was examined by a competent optician who was the leading man in that line in this country, and he developed the tests of the finished product at the Bausch & Lomb factory.

To sum up the situation, it might be said that these men furnished to the art in this country the annealing process, the stirring process, and that they cooperated in the development of a type of crucible used for melting glass. They also evolved the physical tests for purity of material and optical properties of the finished product.

This cooperation on the part of the Carnegie Institution laboratories was largely instrumental in helping the Bausch & Lomb Optical Co., the Pittsburgh Plate Glass Co., and the Spencer Lens Co. to establish quantity production of optical glass.

One of the difficulties that was encountered in the solution of this problem was that of getting pure sand, and those having charge of this work scoured the United States and finally found a deposit of sand in southern Michigan which answered the purpose. The results of the work were that from a quantity production of less than 1 ton per month in April, 1917, there was an increase to 100 tons per month at the time of the armistice. The glass produced was as good as the best German glass, except for a slight cloudiness due to impurity in the sand, but for all practical purposes the glass was just as good as the best German glass.

The interlocking activities of the members of the Naval Consulting Board in various scientific activities of the Government has been pointed out in another place in this book, but it may not be amiss to state that both Dr. Baekeland and Dr. Woodward were members of the National Research Council as well as the Naval Consulting Board, and although the evidence seems to be sufficient to warrant the statement that Dr. Baekeland's activities brought about the hearty cooperation of the Carnegie Institution in the production of optical glass, yet the National Research Council also had put in a request for the use of the geophysical laboratory of the Carnegie Institution almost simultaneously with that made by Dr. Baekeland in his capacity as a member of the Naval Consulting Board. The subsequent work of the Carnegie Institution in the production of optical instruments for artillery, at Pasadena, Calif., was conducted under the direction of Dr. George E. Hale, director of the Mount Wilson Observatory and laboratory at Pasadena, and was also chairman of the National Research Council. Therefore the relation between the Carnegie Institution and the National Research Council was just as close, if not closer, than that between the Naval Consulting Board and the institution.

The men on the Naval Consulting Board were anxious to help win the war, and the question of the capacity in which they were acting at the time they initiated or developed certain instrumentalities for winning the war was of a secondary consideration. Probably it did not enter Dr. Woodward's mind whether his activities were conducted in his capacity as a member of the Naval Consulting Board or as a member of the National Research Council. The cardinal thing is that the cost to the physical laboratory of the Carnegie Institute, of its contribution to the Government in the solution of the optical-glass problem, amounted to about $200,000, and that the results justified this expenditure.

To show how matters like the solution of the optical instrument and glass problems touched different organizations, it should be mentioned that when the supply of optical instruments was seriously behind its schedule in 1918, the War Industries Board took charge of the entire optical instruments industry in the country.

It will be recalled that the Naval Consulting Board started the industrial preparedness campaign, that the outgrowth of that campaign was the Council of National Defense, and that the outgrowth of one of the committees of the Council of National Defense was the War Industries Board, which received the results of the activities of the Carnegie Institution in the production of optical glass, which activity on the part of the Carnegie Institution had been evolved by two members of the Naval Consulting Board, Dr. Baekland and Dr. Woodward.

NORTH SEA MINE BARRIER.

The wide publicity which was given the Naval Consulting Board in its formation no doubt started many men on the development of ideas for devices to win the war, and it is almost impossible to say to what an extent the act of creating the Naval Consulting Board influenced the subsequent development and production of new inventions.

Many inventions were submitted directly to the governmental departments which were dealing with the particular subject of the invention, and this also occurred in regard to the Navy Department, for although the Naval Consulting Board received thousands of ideas and suggestions, yet this did not preclude men of ability from going directly to the various bureaus of the Navy with their inventions.

Probably one of the most important naval inventions made during the war was that of Ralph C. Browne, of Salem, Mass., who developed a design for a submarine gun which incorporated in it certain elements which had great possibilities if adopted for use in mines. This fact was recognized by the Chief of the Bureau of Ordnance, Ralph Earle, and Assistant Chief. Capt. T. A. Kearney, together with Commander S. P. Fullinwider, United States Navy, and his assistant, Lieut. Commander T. S. Wilkinson, jr., United States Navy. As a result of the recognition by these men of the device created by Mr. Browne, it became an important part of the mines which were used in creating the North Sea mine barrier between the Orkney Islands and Norway, which project had been under consideration for many months by the Bureau of Ordnance.

This invention of Mr. Browne's was called to the attention of the Naval Consulting Board at a meeting of the members, which had been arranged in the Engineering Building, New York City; but, owing to the circumstances under which the meeting took place, there being a great number of people present, and the fact that Mr. Browne, under these circumstances, did not feel at liberty to disclose the important features of his invention, its value was not disclosed to those of the Naval Consulting Board who talked with him. Mr. Browne immediately took the matter up with the Navy Department directly, and the value of this contribution was immediately recognized, as above stated.

As the North Sea barrier was one of the important elements in defeating the submarine, it being understood that between 17 and 23 submarines were lost there, and the fact that many people hold that the surrender of the German fleet and the armistice were brought about largely by the failure of the submarine warfare, and that this failure occurred almost as soon as the mine barrier was found to be effective, the value of this contribution of Mr. Browne's is realized.

The whole barrier contained some 70,117 mines, of which 56,571, or four-fifths, were laid by the United States. This mine field covered a distance of 230 miles.

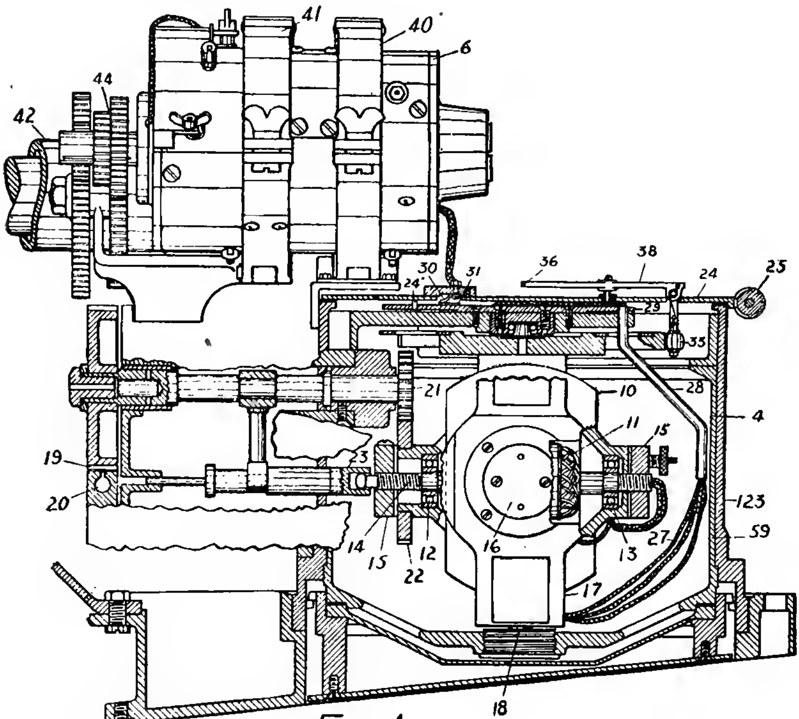


Fig. 1.

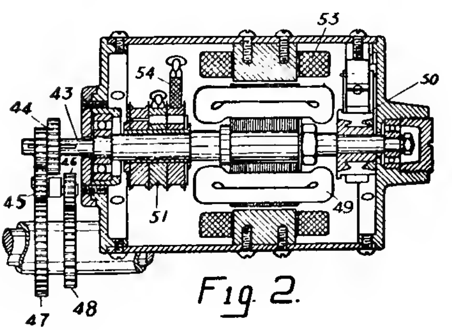


Fig. 2.

CHAPTER XIII.

CONCLUSION.

The results obtained by Secretary Daniels through the creation of machinery and facilities for utilizing the inventive genius of Americans to meet the new conditions of warfare as shown abroad, by the organization of the Naval Consulting Board in the manner in which it was formed—that is, by inviting Mr. Thomas A. Edison to head such a board, and then by having 11 of the large engineering societies of the country make up the personnel of the board—brought about results which were in harmony with the method taken in the formation of the board.

By this method of selection there was gathered together in this board, together with certain men of inventive talent, a large number of business executives whose success had come about through their ability as engineers and inventors, but who, at the time that they were selected for the board, were preeminently executives of large business enterprises, with an outlook on life which comes from the point of view obtained by the control over large forces of men.

It is not surprising, therefore, that the first work undertaken by the board was one of a fundamental character that went to the very roots of the question of national defense—that is, industrial preparedness. As pointed out in the chapter on the "Industrial Preparedness Campaign," this was inaugurated largely through the efforts of Mr. Howard E. Coffin; but he had the hearty cooperation and sympathy of all members of the board and the benefit of the executive and administrative ability of the members of the board who were particularly qualified to render him such aid.

It would have been difficult for Secretary Daniels to realize in July, 1915, when he wrote his letter to Mr. Edison asking him to be advisor to a board which would mobilize the inventive talent of the country, that he would thus set in motion forces that would bring about the rebirth of the country's thought in regard to preparedness and war, and determine to some extent at least that the war should be conducted by the business men and engineers of the country in place of those having high political places in national affairs.

Had an industrial inventory of the country been taken by Government officials instead of by the engineering societies, and without the

Nation-wide propaganda and advertisement by which the country was educated in preparedness by the Naval Consulting Board, there is every probability that the Nation would not have been ready for the war when it did come. It is also probable that some other organization would have been evolved to bring about the union of the Army, Navy, and the industries of the country, other than such a unique body as the Council of National Defense and its Advisory Commission with its broad powers, which were little short of those of a War Cabinet.

The next important thing which the board took up after the inventory, was the solving of the fuel-oil problem of the Navy Department, which enabled the department to formulate its policy for naval development and the use of fuel oil on battleships on the firm foundation of the best knowledge in the country on that point. Here again the ability of the engineers, business men, and executives of the board was displayed in their knowledge of men and affairs and ability to gather together men of such a character as to put at the disposal of the Navy Department the requisite information.

This same method of handling things was displayed in the method that the board took to meet the submarine menace at the time we entered the war. As heretofore pointed out, the first thought was to investigate the whole problem from the bottom up, and come to a conclusion as to the best method of attack on it.

It will also be recalled that a conference was called before we entered the war to which prominent naval officers and scientists were invited, and that as a result of this conference it was decided that the proper line of attack was to evolve some method for locating submarines by listening devices. In the chapter on special problems was pointed out the history of the development of this movement, and the resultant successful solution of the problem. The submarine menace was solved by a combination of the listening device, the depth bomb, the destroyer, and the convoy system.

The conquering of the submarine was a dual problem, in that it also involved protecting the merchant vessels with the best inventions possible, as well as equipping warcraft with devices; and here the business judgment of the members of the board was displayed in their cooperation in the formation of the Ship Protection Committee of the United States Shipping Board, and the placing of one of the Naval Consulting Board members upon that committee, thus bringing about a close cooperation between the Navy and the Naval Consulting Board and those in control of the merchant marine.

This same ability was also displayed in the handling of the matter of getting reports on a new naval base for the Pacific coast. The machinery which had been evolved for the taking of the industrial inventory was used in getting the facts for the solution of this problem.

The board also saw the necessity during the first few months of its activities of having adequate laboratory facilities for the development of ideas of an inventive character. Largely through the influence of the members of the board and their reputation in the community, Congress, after thorough hearings on this matter, made an appropriation for a naval laboratory which the Navy had been unable to get from Congress therefore, although it had been desired for many years.

There were, however, selected for membership on the board men of recognized inventive ability, many of them with laboratories and staffs of their own which they were utilizing themselves for the creation of war inventions. These men therefore devoted themselves to the creation of inventions, and the results of their work, which are fully set forth in the chapter on "Inventive Accomplishments of Members," is most interesting and instructive, especially when the accomplishments of these few men are compared with the accomplishments of the public in general, who submitted more than one hundred thousand ideas, out of which but one, possibly two, were put into production for the use of the Navy.

This shows conclusively that in mobilizing inventive talent there must be a selective mobilization of those who are best qualified to do the work, and not the mobilization of the untrained talent of the country on the hope that a brilliant invention will come from it.

The members of the board were not limited by their specialties, but there was a tendency for members to gravitate to and work with the particular arts with which they were most familiar.

Those who had invented appliances in the electrical art devoted themselves to those things which are closely related to their knowledge; those who had long been working with explosives naturally devoted a great deal of their time to devices incorporating the principles of that art; those familiar with machinery on warships turned their attention to those things and worked upon the designs of torpedo-proof ships.

Others devoted themselves to marine inventions for the protection of merchant vessels; others to miscellaneous inventions as would naturally be expected from them; others to the development of scientific instruments for Army and Navy use and the creation of additional devices in the same class. On the whole, through the work of these men in the Naval Consulting Board, many scientific problems were advanced for future use and development even though they were not brought into effective use in the World War.

Everyone expected that the board would evolve some invention that would conquer the Central Powers with one fell swoop, and had the war lasted another year an important and confidential device not described herein would have probably justified this expectation in a degree at least; and other devices evolved by the board, such as wireless-controlled bombs, devices for the automatic introduction of all the factors in the aiming of machine guns on aeroplanes, as well as others, gave promise of such results.

In its handling of inventions from the public, the board collected information as to where the available inventive talent of the country is to be found, and deduced that the best results came from team work on inventions, such as that utilized by the Special Problems Committee of the board in its work of developing listening devices at Nahant, especially so when such teams are made up of highly trained technical men, each contributing something to the solution of the problem.

In conclusion it may be said that the patriotic and whole-hearted service which members of the Naval Consulting Board at the request of a progressive Secretary of the Navy rendered to the Government during one of the most trying periods in the history of the United States, was something to reinforce our faith in human nature and the democratic institutions on which our Government is founded.

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APPENDIX.

NAVAL LABORATORY.

Report of Committee on Sites.

In arriving at a conclusion as to which site on the whole presents the greater advantages under existing conditions, it is essential to consider, first, the *authority for and functions of the naval laboratory*, and, second, the *manner in which it must be operated.*

The act making appropriations for the Naval Service for the fiscal year ending June 30, 1917, provided as follows:

Experimental and research laboratory: For laboratory and research work on the subject of gun erosion, torpedo motive power, the gyroscope, submarine guns, protection against submarine, torpedo and mine attack, improvement in submarine attachments, improvement and development in submarine engines, storage batteries and propulsion, aeroplanes and aircraft, improvement in radio installations, and such other necessary work for the benefit of the Government service, including the construction, equipment, and operation of a laboratory, the employment of scientific civilian assistants as may become necessary, to be expended upon the direction of the Secretary of the Navy (limit of cost not to exceed $1,500,000), $1,000,000: *Provided*, That nothing herein shall be construed as preventing or interfering with the continuation or undertaking of necessary experimental work during the fiscal year ending June thirtieth, nineteen hundred and seventeen, as heretofore conducted under other appropriations: *Provided further*, That the Secretary of the Navy shall make detailed reports to the Congress not later than June thirtieth, nineteen hundred and seventeen, and annually thereafter, showing the manner in which all expenditures hereunder have been made.

The original conception was for a laboratory involving an outlay of almost $5,000,000, in which not only research and experimental work but heavy construction of all kinds could be rapidly carried on; but after full hearing by the Naval Committees the total proposed for construction and operation was cut to $1,500,000, of which only $1,000.000 has actually been authorized; and this at a time of increases of from 25 to 100 per cent in costs of labor and materials. The terms of the act make even this appropriation cover not only construction and equipment but all operating expenses until further provision.

Because of this great, and in many respects, regrettable reduction in the appropriation, and the serious limitations resulting therefrom, it is vital that in order to make the most of the available funds there should be no unnecessary duplication of equipment and facilities which already exist in other Government plants, and no avoidable expenditures outside of buildings and equipment.

For instance, land and water approach costs must be minimized, and the idea of construction of large guns, or vessels of any type, or the manufacture along commercial lines of large numbers of any kind of equipment must be abandoned. All heavy work must be and should be built, and undoubtedly can be better built, at other places, and only comparatively light work based upon research and experiment should be carried on at the laboratory.

As to the manner in which it should be operated, the idea that the work should be more or less under the direction of bureau chiefs, individually or collectively, or the members of the Naval Consulting Board, should be discarded, for such would lead to a many-headed and inefficient organization.

Instead, the laboratory should be under a responsible officer of high rank, to whom the various bureau chiefs should turn over their problems, accompanied by all available information. And so, too, with regard to problems which may be submitted to the Consulting Board.

It will undoubtedly be necessary to frequently call upon the bureaus for advice and information, but it will not be necessary for the chiefs to make frequent visits to the laboratory. This fact, while making reasonable access from Washington desirable, removes the necessity of the laboratory being immediately in the proximity of the Navy Department. Moreover, a large part of the work will consist of purely scientific research and experiment, which will require a reasonable amount of isolation and freedom from interference and criticism.

With the foregoing general concepts, consideration of various sites was taken up, with specific reference to a number of characteristics each more or less influential in arriving at a decision.

Of the nearly 60 sites which have been formally presented, on public and private lands, from New Hampshire to Louisiana and all east of the Mississippi River, but few could be considered favorably; in any event, before investigating privately owned lands, it was necessary to ascertain whether there was available land directly controlled by the Navy Department which would meet the necessary requirements.

With these considerations in view, members of the committee have made a detailed investigation of a number of localities in and about New York, and also of the League Island Navy Yard at Philadelphia, the site of the present experimental station at Annapolis, and the Belleview Magazine site at Washington.

Each of the above places possesses a number of the requirements which are deemed essential; none, of course, possesses them all.

Broadly speaking, the decision as to site finally narrowed down to a selection in the vicinity of the National Capital or New York, the president of the board, Mr. Thomas Edison, preferring the latter and the remaining five members of the committee being unanimously in favor of the former.

The difference of opinion is based upon somewhat different conceptions of the functions of the experiment station and laboratory and especially of the relation of the Navy to it.

The president's point of view may be expressed briefly as follows: That Sandy Hook has ample ground available, and, although an Army reservation, probably can, without unreasonable delay, be transferred to the Navy Department; that it has water on both sides of fair depth; that it is within a comparatively short distance from New York, where there is a large market for materials and labor, and is reasonably accessible to workmen and visit by members of the Naval Consulting Board. He feels that the laboratory should be essentially a development machine shop run at high pressure when necessary, and with but limited research facilities; that most of the basic facts necessary are already known; and that such extra research work as may be required can be carried on at such places as the Bureau of Standards, Washington, or at various private experimental research laboratories throughout the country. He also thinks that both direction and operation should be essentially civilian and largely divorced from naval influences and control, while with regard to future requirements he believes that if the laboratory makes good there will be no difficulty in getting all the money that is necessary.

Disagreeing with these opinions, the remaining five members of the committee state their views, first, as to Sandy Hook, and, second, as to their final choice, as follows:

The acquisition of Sandy Hook, being part of an Army reservation, might be materially delayed, while time is the essence of successful development not merely in machine construction but in getting the laboratory started and letting the Navy Department and Congress see tangible results. It is not, we believe, as accessible as claimed, for the experience of individual members has been that to spend any appreciable time for investigation, even at the present proving grounds, the entire day must be given to the work.

While naval officers vary in their opinions as to other places, for and against, not a single one has expressed himself as in favor of this particular location. The speeding of work, so far as the handling of machine tools and men are concerned, can under proper regulations and authority be conducted in one place as well as in another.

In the determination of locations for the proposed nitrate and armor-plate plants freedom from attack has been given due importance. Sandy Hook is subject to direct naval attack at long range. The presence of the proving grounds, with heavy and irregular gunfire, is objectionable and the place offers poor facilities for aeroplane or other outside tests in winter.

It is impossible to separate proper research and machine development, and since the problems to be solved are essentially naval ones, to disassociate control and operation of the plant from the naval service, for whose specific benefit it is being projected, would be most unfortunate. The calling in of outside research or experimental laboratories on confidential matters would be a matter of grave concern, and the experience of the Navy Department, as well as that of some of the members of the board, in this connection affords little ground to hope for efficiency by such references.

It is with reluctance that the majority members of the committee find themselves obliged to disagree with the chairman in the conclusions arrived at, conclusions which it seems are in the main essential, especially in view of the wide difference between the cost and scope as originally outlined of the experiment station and as finally authorized in the naval appropriation bill.

FINAL CONCLUSIONS.

After careful consideration of the whole subject we recommend as the best selection the site on which the present experimental station at Annapolis, now under the Bureau of Steam Engineering, is situated; also that this station be removed from bureau control and consolidated with the proposed laboratory and experimental station, under the direction of a naval officer distinguished by his scientific attainments and managerial capacity, who should report directly, so far as it is practicable, to the Navy Department.

The special characteristics noted are as follows:

(1) *Location, ownership, and available area, both of land and water.*—On the bank of the Severn River, opposite the Naval Academy, and at present under the general jurisdiction of its superintendent; nearly 100 acres out of a total of about 300 are available; ample water front.

(2) *Character of land and purchase cost, or the cost of changing contour.*—No purchase cost and but low cost of changing contour, even with extensive building operations; land offers excellent foundations.

(3) *Water front, depth of water, and proximity of navigable channel.*—Ample frontage, with a fine masonry dock already constructed, a 29-foot channel, and room within three miles to anchor the entire Atlantic Fleet. The channel from Baltimore to the mouth of the Severn is dredged to a minimum depth of 35 feet.

(4) *Character of bottoms and stability of channel.*—Easily dredged, if required, and with practically no shifting changes in channel.

(5) *Amount of dreding if necessary, and liklihood of ice.*—Depends upon how large a ship is desired to bring close to the laboratory, but it would seem that accessibility of a dreadnought to the dock is unnecessary; there is but little ice formation.

(6) *Range of tide and character of water—whether fresh, brackish, or salt.*—Low tidal change; water unusually clean and clear from sand and sewerage, and although not strictly sea water of the same composition as the ocean, contains a considerable amount of salt.

(7) *General climatic conditions.*—Good for all-year work, and better in summer than Washington.

(8) *Character of neighborhood, considered from a residential standpoint.*—In the main excellent, and near enough to Washington for reasonable additional social diversions.

(9) *Character of labor market.*—While not a manufacturing center, and hence not available for quickly changing demands for mechanics, such would form but a moderate proportion of the people employed, many of whom would be civilian scientists, naval officers and possibly men from the enlisted forces who have developed special aptitude. About 100 men are already employed, some of whom actually live in Baltimore; but it is a trite saying that labor follows the market, and if there should be here established a larger and more important experimental station of the kind now authorized, employing, not spasmodically and erratically, but steadily, skilled men, many would eventually make Annapolis their home.

(10) *Market for materials.*—Ordinary operation does not require a hand-to-mouth condition calling for daily dependence upon the jobbers of a great city. Of the manufacturing establishments throughout the country large numbers are remotely situated from, and are independent of, New York, and there is no good reason why with proper management the proposed laboratory should not be well enough stocked to be similarly independent. Baltimore is within 50 minutes by trolley and 24 miles by water, and materials can be delivered every day of the year.

(11) *Availability of other Government machinery and facilities.*—The nearest Government shops where large work can be done are at Washington, Norfolk, and Philadelphia, but all are available; and once it is necessary to have such work done outside of the experimental station a few miles more or less is a matter of small importance. Moreover, the important Indian Head proving grounds are within a comparatively short distance.

(12) *Availability of Government records, scientific and patent information, and officers of bureaus for consultation.*—Washington is within two hours by electric railway; and, in addition, the governor of Maryland states that there will be constructed within two years a 26-mile boulevard direct to Washington, which can be easily covered by automobile within an hour. Recent rules permit the purchase of service automobiles in all departments of the Navy when this is required for prompt transportation. From the Navy Department must issue all original plans of construction, and there, too, all records are available. In Washington there are the Government's most important large gun factory, the experimental basin and wind tunnel, the Patent Office, Bureau of Standards, and various other sources of such special information as may be occasionally required. All are within reasonable traveling distance and short telephonic communication.

(13) *Accessibility of historical models and records, as well as standard and proposed naval equipments.*—In addition to those available in Washington, the steam and electrical engineering laboratories at the Naval Academy and the products of the existing experimental laboratory are at hand.

(14) *Accessibility for civilian scientists, whether members of the Consulting Board or regularly employed.*—Convenience to the members of the board itself is not of first importance, as they will not be employed in the laboratory and can not, of course, operate it. Moreover, the present composition and residence of the board aré subject to radical changes. As to the other scientists,

Annapolis, Washington, and Baltimore are all available, in less time, for example, than the residential part of New York would be from Sandy Hook.

(15) *Sentiment of naval officers.*—The sentiment of most of those of wide experience seems to be strongly in favor of either Annapolis or Washington, while some who have not seen Annapolis in a score of years prefer New York. Where a difference of opinion does exist, it seems to largely be founded upon the assumption that the laboratory is to be an annex to the various bureaus, and largely under their direction, which point of view seems incorrect. Where a preference for New York has been voiced, it has been invariably accompanied by the opinion that the location should be on the mainland, easily accessible to either Manhattan or Brooklyn. There is no such land available.

(16) *Secrecy and efficiency of operation and safety from enemy assault.*—Admirably situated to be free from ordinary interference and unauthorized visits, and offers much easier supervision of employees. It is reasonably free from enemy attacks and easily defended if necessary by a fleet. Climatic conditions and lay of land and water lend themselves to outside tests, for example, of aeroplanes throughout the year. The location is also free from the disturbance of gunfire.

(17) *Concentration of experimental work and development.*—The present experimental station, in operation for some years, represents a direct investment of about a half million dollars, and the existing facilities and equipment could not now be duplicated for less than an additional quarter of a million. About half a million dollars has been expended in carrying on important investigation and tests, now requiring the work of 100 men. This condition is a good beginning, and if there be now added to it such extensions in buildings, equipment, and operation as are possible by the proper expenditure of the million dollars now available and are in view, as well as such as are ordinarily available for the present station, there will be established a dignified and effective equipment, more impressive in results and costing less to operate than two separate experimental stations of like total expenditure. In fact, a considerable more extensive equipment can be insured by extending the present station than by the construction of an independent one; it can be more quickly begun and put in operating condition, and important experimental work would not need to await the completion of the whole. Besides the provisional plans outlined sometime ago by the chairman other plans showing how the present plant can be extended have been outlined, and as soon as an agreement on general features is arrived at work can be instantly begun.

(18) *Congressional support.*—It is vitally important to avoid those sectional influences which often times interfere with administration and especially congressional support, instances of which are too numerous to need specific mention. At Annapolis, as at Washington, the laboratory would be on national territory and can be developed along national lines, in connection with an institution in which every member of Congress has an individual interest, and which can be more readily visited by him than any other place under consideration except Washington.

There are some additional important considerations which must enter into any broad view of this matter, and which should carry weight if this project is to be developed on the highest and most effective plans.

Annapolis is the seat of the United States Naval Academy, the prime source of the professional education of the officers who are especially concerned. It shares with Washington the individuality of national distinction. At the academy itself the Government has within recent years expended in superb housing and educational buildings and electrical and machine equipment considerably over $10,000,000, and this is being constantly augmented. In addition to the educational facilities now extended to naval officers at Columbia, Harvard, and elsewhere, there is here established a post-graduate course which it is hoped may be extended so as to ultimately make less necessary the utilizing of other university facilities.

The graduates of the academy, all of whom must in every way be trained in the practical as well as the theoretical side of their profession, in laboratory and machine shop as well as in the field or on the water, representing in the highest degree the democracy of the country, comprise many men of special fitness for scientific research, to whom the presence of a well-equipped research laboratory and experimental station will be a constant source of inspiration and the ultimate scene of their activities.

This laboratory is primarily designed to benefit the professional service for which these men are being trained, not for the benefit of civilian scientists. It must deal with the peculiarly individual problems of an organization concerning the details and needs of which few laymen, no matter what their experience and attainments in other lines, are familiar. It must necessarily be a Government laboratory and experimental station for the development of specific naval ideas and a contributor to naval needs.

At the same time the actual and possible limitations of its activities must not be lost sight of. It is not intended to rival in investment, equipment, or output great industrial factories or machine shops or do the work legitimately belonging to the navy yards or gun shops. It is primarily intended for a research laboratory, with sufficient ample up-to-date machine-shop facilities to undertake and carry through successfully and rapidly such mechanical work as may properly come within its sphere.

These functions, not those of great construction, if properly carried out, will give this laboratory a national standing, command the confidence of the Navy Department and Congress, and be a source of inspiration and pride to the professional officers of the service, most of whom spend at least four years of the formative period of their professional life at Annapolis, and large numbers of whom are constantly on duty there or at the Capitol.

FRANK J. SPRAGUE.
LAWRENCE ADDICKS.

MINORITY REPORT.

I do not agree with the majority of the committee on the selection of Annapolis as a site for the proposed naval laboratory. I believe this would be a very bad selection if rapidity of construction is to be a dominating feature of the laboratory. I believe the best place for such a laboratory is on the Sandy Hook Peninsula.

The practical advantages of Sandy Hook are as follows:

1. Unlimited amount of flat land away from inhabited places, where experiments can be made unobserved.

2. Where there is an operating proving ground right at hand.

3. Where, near by, there is a highland nearly 300 feet high, invaluable for experimenting on certain strategic devices.

4. Where, on account of the narrow strip of land projecting into the sea, certain experiments and tests can be carried out under more nearly practice conditions than at any other point.

5. That it is an ideal place for aeroplane work, with both smooth and deep-sea conditions, in view of the long coast and beach line of the State.

6. That it gives every facility for experiments with and operation of submarines.

7. That no ornamental or expensive buildings need be constructed, as necessarily there will be no visitors to impress.

8. That the country around Navesink Highlands is the finest in the State for residence. Monmouth County is the richest farming county in New Jersey, and living is cheaper than in almost any other part of the State.

9. That there is ample and rapid transportation facilities for all the men likely to be employed in the laboratory.

10. That there are more houses, at very moderate rents, procurable in the 13 cities and towns adjacent to the Hook than at any other point. My investigator already reports houses for 500 families can be obtained at very moderate rental close by the Hook and that conditions in that respect are ideal.

11. That the laboratory buyer in New York can by telephone procure and ship any supplies to the Hook by the small motor boat owned by the laboratory quicker than at any other site, the distance requiring one hour by this boat and two and a half hours by railway.

12. That freight from two railways can be taken right to the laboratory on the Government railroad at the Hook, and water-borne freight can be delivered at the dock of the laboratory.

13. In ordinary manufacturing districts employees are constantly coming and going, the number in most cases amounting to about 60 per cent of the turnover of all employed. Sandy Hook region not being a manufacturing district, I think the men employed at the laboratory will not be so liable to change.

14. New York now is, I believe, the largest city in the world. It is the greatest market in this country. In New York nearly every article sold in the United States can be found in stock. In the city and vicinity of New York is the greatest collection of factories in the country making the most diverse articles, and all this vast variety of materials can be instantly placed at the disposal of the laboratory.

15. A majority of the great industries of the country have a New York office, and most of the higher officials reside there. To these men we can appeal for small supplies urgently needed at once, thus eliminating the usual months' mill delay, and in my opinion we will get them.

16. There are certain strategic devices which can only be perfected over the ocean itself, especially where many large ocean-going steamers are passing night and day, where haze, fogs, and high winds often prevail, and these necessary conditions are found at Sandy Hook.

17. The Navy will be certain to have more problems to solve than those set forth in the appropriation bill, and it may also be expected soon that Congress may want the laboratory to construct and test Army devices cooperatively with the Navy.

This I have taken in consideration in suggesting Sandy Hook.

As to the character of the laboratory itself, I recommend that it be one that is constructed, arranged, and run as a works for the rapid construction and test of experimental machines and devices; that it be operated on a war basis, where speed of construction is the dominating motto; that it be operated in three shifts of eight full hours each; that every machine should be given out to the workmen in parts, one man to a part, to the end that when the part which takes the longest time to make is finished, the whole machine is finished; that these parts are spread all over the works and then brought together in an assembly shop, where they can be put together by trustworthy men, preserving a secrecy which is practically impossible in the usual shop.

I do not think that scientific research work to any great extent will be necessary. Research work in every branch of science and industry, costing countless millions of dollars and the labor of multitudes of men of the highest minds, has been carried on for many years. All of this has been recorded, and yet only a ridiculously small percentage has as yet been applied and utilized. It is therefore useless to go on piling up more data at great expense and delay while we are free to use this ocean of facts.

There will, of course, arise many things that require a special research. Much of this can be done at the proposed laboratory, but in certain branches of science it would be better to use the facilities and the researchers at the other Government bureaus, such as the Bureau of Standards, Bureau of Chemistry, and many others and also the exceptionally able men who are the heads of many industrial research laboratories. I do not fear that there would be trouble about secrecy among the latter.

As to the management of the proposed laboratory, I believe it should be civilian. Also that the civilian Secretary of the Navy should control through an appointed naval officer, preferably one who has been or now is an industrial manager of a navy yard, and that no naval officers who have their own duties should interfere in any way. I also think that we should proceed to experiment on the special devices mentioned in the appropriation, as well as such other devices as the naval officers sketch out and pass on to the laboratory through the secretary; also any other devices suggested from outside sources which the Secretary of the Navy thinks should be made.

In concluding this report I want to suggest that it may be well to consider the erection of temporary buildings, very inexpensive but really as good as more costly ones, and which would last for many years and be fireproof. At any time the site could be changed or permanent buildings erected and any mistake of judgment could be corrected at small expense, and the laboratory would quickly be put in operation.

I expected to have this minority report ready to be forwarded with the majority report, but I was busy and did not have time to prepare it quickly enough.

THOMAS A. EDISON.

FUNCTIONS AND ORGANIZATION OF SUBCOMMITTEES OF EXECUTIVE COMMITTEE OF NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

[Approved by resolution of executive committee, May 20, 1919.]

The executive committee shall have six subcommittees, to be known as standing committees on (*a*) aerodynamics; (*b*) power plants for aircraft; (*c*) materials for aircraft; (*d*) personnel, buildings, and equipment; (*e*) publications and intelligence; (*f*) governmental relations.

These standing committees may, from time to time, appoint special subcommittees with the approval of the executive committee.

The functions and membership of the standing committees shall be as follows:

AERODYNAMICS.

Functions.—The functions and duties of this committee shall be:

1. To aid in determining the problems relating to the theoretical and experimental study of aerodynamics to be experimentally attacked by governmental and private agencies.

2. To endeavor to coordinate, by counsel and suggestion, the research and experimental work involved in the investigation of such problems.

3. To act as a medium for the interchange or information regarding aerodynamic investigations in progress or proposed.

4. The committee may direct and conduct research and experiment in aerodynamics in such laboratory or laboratories, either in whole or in part, as may be placed under its direction.

5. The committee shall meet from time to time on call of the chairman, and report its actions and recommendations to the executive committee.

Organization.—Chairman, Dr. John F. Hayford; vice chairman, Dr. Joseph S. Ames; Prof. Charles F. Marvin; Col. T. H. Bane, U. S. Army; Lieut. Col. V. E. Clark, U. S. Army; Dr. A. F. Zahm; Lieut. Commander J. C. Hunsaker, U. S. Navy; Dr L. J. Briggs; Mr. M. D. Hersey; Mr. E. P. Warner, secretary.

POWER PLANTS FOR AIRCRAFT.

Functions.—The functions and duties of this committee shall be:

1. To aid in determining the problems relating to power plants for aircraft to be experimentally attacked by governmental and private agencies.
2. To endeavor to coordinate, by counsel and suggestion, the research and experimental work involved in the investigation of such problems.
3. To act as a medium for the interchange of information regarding aeronautic power-plant investigations, in progress or proposed.
4. The committee may direct and conduct research and experiment on aeronautic power-plant problems in such laboratory or laboratories, either in whole or in part, as may be placed under its direction.
5. The committee shall meet from time to time on call of the chairman, and report its actions and recommendations to the executive committee.

Organization.—Dr. S. W. Stratton, chairman; Mr. L. M. Griffith; Prof. George W. Lewis; Maj. George E. A. Hallett, U. S. Army; Mr. J. G. Vincent; Mr. Harvey N. Davis; Dr. H. C. Dickinson, acting secretary; one member to be nominated by the Navy Department.

MATERIALS FOR AIRCRAFT.

Functions.—The functions and duties of this committee shall be:

1. To aid in determining the problems relating to materials for aircraft to be experimentally attacked by governmental and private agencies.
2. To endeavor to coordinate, by counsel and suggestion, the research and experimental work involved in the investigation of such problems.
3. To act as a medium for the interchange of information regarding investigations of materials for aircraft, in progress or proposed.
4. The committee may direct and conduct research and experiment on materials for aircraft in such laboratory or laboratories, either in whole or in part, as may be placed under its direction.
5. The committee shall meet from time to time on call of the chairman, and report its actions and recommendations to the executive committee.

Organization.—Dr. S. W. Stratton, chairman; Dr. G. K. Burgess, vice chairman; Lieut. Col. H. C. K. Muhlenberg, U. S. Army; Lieut. Commander J. C. Hunsaker, U. S. Navy; Mr. H. L. Whittemore, acting secretary.

PERSONNEL, BUILDINGS, AND EQUIPMENT.

Functions.—The functions and duties of this committee shall be:

1. To handle all matters relating to personnel, including the employment, promotion, discharge, and duties of all employees and others assigned to the committee for duty.
2. To consider questions referred to it and initiate projects concerning the erection or alteration of buildings and the equipment of buildings, offices, and houses, etc.
3. To meet from time to time on call of the chairman, and report its actions and recommendations to the executive committee.

4. To supervise such construction and equipment work as may be authorized by the executive committee.

Organization.—Dr. Joseph S. Ames, chairman; Dr. S. W. Stratton, vice chairman; Prof. Charles F. Marvin; Mr. J. F. Victory, secretary.

PUBLICATIONS AND INTELLIGENCE.

Functions.—The functions and duties of this committee shall be:

1. The collection, classification, and diffusion of useful knowledge on the subject of aeronautics, including the results of research and experimental work done in all parts of the world.

2. The encouragement of the study of the subject of aeronautics in institutions of learning.

3. Supervision of the office of aeronautical intelligence.

4. Supervision of the foreign office in Paris.

5. The collection and preparation for publication of the annual report and its appendixes.

Organization.—Dr. Joseph S. Ames, chairman; Prof. Charles F. Marvin, vice chairman; Miss M. M. Muller, secretary.

GOVERNMENTAL RELATION.

Functions.—The functions and duties of this committee shall be:

1. Relations of the committee with executive departments and other branches of the Government.

2. Governmental relations with civil agencies.

Organization.—Dr. Charles D. Walcott, chairman; Dr. S. W. Stratton; Mr. J. F. Victory, secretary.

[Treasury Department, Bureau of War Risk Insurance. Form 26.]

FORM OF CERTIFICATE FOR COLLECTORS OF CUSTOMS RELATING TO THE INVISIBILITY OF VESSELS NAVIGATING THROUGH THE WAR ZONE.

Date ____________________________

THIS IS TO CERTIFY that S.____
now at this port, bound for ____

(*a*) Has been satisfactorily painted in accordance with the scheme furnished by the Bureau.

(*b*) Has a supply of ____________________ tons of anthracite coal in bunkers, which I consider sufficient for two daylight runs;

Or—

Is fitted with an improved system of smoke prevention.

(*c*) Is equipped with one dozen approved smoke boxes which will evolve smoke when thrown overboard.

[Treasury Department, Bureau of War Risk Insurance. Form 29.]

____________________, 191__

This is to certify that S. S. ____
owned by ____
has been painted in accordance with a system for low visibility submitted by ____ and approved by the Chairman of the Naval Consulting Board, 11 Broadway, New York City.

____
(Shipowner.)

Painting completed, ________________________, 191__

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Rear Admiral W. S. Sims, U. S. Navy, president Naval War College, commander Narragansett Bay Naval Station.

Capt. W. S. Smith, U. S. Navy, special duty, Navy Department, in connection with Naval Consulting Board and inventions.

Commander J. K. Robison, U. S. Navy, inspector of ordnance, torpedo station, Newport, R. I.

Commander Yates Stirling, jr., U. S. Navy, commanding submarine base, New London, Conn.

Lieut. Commander G. W. S. Castle, U. S. Navy, Bureau of Steam Engineering, Navy Department, Electrical Division.

Naval Constructor E. S. Land, U. S. Navy, Bureau of Construction and Repair, Navy Department, Electrical Division.

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A. I. E. E.—John H. Finney, 509 Metropolitan Bank Building, Washington; southern manager Aluminum Co. of America.

A. C. S.—Charles L. Parsons, box 505, Washington; United States Bureau of Mines.

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A. I. E. E.—O. G. F. Markhus, 701 Bannock Street, Boise; general superintendent Electric Investment Co.

A. C. S.—J. Shirley Jones, Moscow; director of experiment stations and chemist, University of Idaho.

Illinois:

A. S. C. E.—R. W. Hunt, 2200 Insurance Building, Chicago.

A. I. M. E.—Frederick K. Copeland, 122 South Michigan Avenue, Chicago; president Sullivan Machinery Co.

A. S. M. E.—Dr. W. F. M. Goss, Urbana; dean college of engineering, University of Illinois.

A. I. E. E.—P. Junkersfeld, 72 West Adams Street, Chicago; Commonwealth Edison Co.

A. C. S.—William Hoskins, Room 2009, 111 West Monroe Street, Chicago; Mariner & Hoskins.

Indiana:

A. S. C. E.—Wm. K. Hatt, Lafayette; professor of civil engineering, Purdue University.

A. I. M. E.—Geo. P. Hulst, One hundred and fifty-first Street and McCook Avenue, East Chicago; International Lead Refining Co.

A. S. M. E. Geo. O. Rockwood, 1801 English Avenue, Indianapolis; president Rockwood Manufacturing Co.

A. I. E. E.—F. S. Hunting, Fort Wayne; vice president and general manager Fort Wayne Works of General Electric Co.

A. C. S.—H. E. Barnard, Statehouse, Indianapolis; State food and drug inspector, commissioner weights and measures.

Iowa:

A. S. C. E.—Geo. H. Boynton, German-American Savings Bank Building, Muscatine; president Northern Gravel Co.

A. I. M. E.—E. A. Sayre, 201 Seventh Street, Des Moines; general manager Eagle Coal & Mining Co.

A. S. M. E.—S. M. Woodward, Iowa City; professor of mechanics, State University of Iowa.

A. I. E. E.—Norman T. Wilcox, Keokuk; sales manager Mississippi River Power Co.

A. C. S.—W. F. Coover, Ames; chairman department of chemistry, Iowa State College.

Kansas:

A. S. C. E.—D. H. Whitmer, P. O. Box 233, Pittsburg; president and general manager Whitmer Contracting Co.

A. I. M. E.—T. B. Gearhart, Iola; metallurgist, Prime Western Spelter Co.

A. S. M. E.—A. A. Potter, Manhattan; dean division of engineering, Kansas State Agricultural College.

A. I. E. E.—Geo. C. Shaad, Lawrence; professor of electrical engineering, University of Kansas.

A. C. S.—W. A. Whitaker, Lawrence; associate professor of metallurgy and division State chemical research, University of Kansas.

Kentucky:

A. S. C. E.—Richard Montfort, Louisville; Louisville & Nashville Railroad Co.

A. I. M. E.—Frank D. Rash, Earlington; vice president and general manager St. Bernard Mining Co.

A. S. M. E.—W. S. Speed, 325 West Main Street, Louisville; president Louisville Cement Co.

A. I. E. E.—Carl P. Nachod, 4777 Louisville Avenue, Louisville; president Nachod Signal Co.

A. C. S.—A. M. Breckler, 503 Kentucky Title Building, Louisville; Janes & Breckler.

Louisiana:

A. S. C. E.—Arsene Perrilliat, 822 Hibernia Building, New Orleans; M. E. Hercules Co. (Ltd.).

A. I. M. E.—John B. Hawley, Shreveport.

A. S. M. E.—A. M. Lockett, 533 Baronne Street, New Orleans; president A. M. Lockett Co. (Ltd.).

A. I. E. E.—M. S. Sloan, 201 Baronne Street, New Orleans; general manager New Orleans Railway & Light Co.

A. C. S.—W. L. Howell, Room 314, United States customhouse, New Orleans; chemist in charge, Appraiser's Laboratory.

Maine:

A. S. C. E.—E. C. Jordan, 31½ Exchange Street, Portland; temporary.

A. I. M. E.—R. H. Richards, Boston, Mass.; professor of mining engineering, Massachusetts Institute of Technology.

A. S. M. E.—J. S. Hyde, Bath; president Bath Iron Works.

A. I. E. E.—W. S. Wyman, Augusta; treasurer and general manager Central Maine Power Co.

A. C. S.—Martin L. Griffin, Rumford Falls.

Maryland:

A. S. C. E.—H. D. Bush, Box 1152, Baltimore; general superintendent, Baltimore warehouse Carnegie Steel Co.

A. I. M. E.—W. H. Peirce, Highlandtown, Baltimore; vice president and general manager, Baltimore Copper Smelting & Rolling Co.

A. S. M. E.—C. C. Thomas, Baltimore; professor of mining engineering, Johns Hopkins University.

A. I. E. E.—J. B. Whitehead, Baltimore; professor of electrical engineering, Johns Hopkins University.

A. C. S.—W. B. D. Penniman, 215 East Fayette Street, Baltimore; Penniman & Browne.

Massachusetts:

A. S. C. E.—Fayette S. Curtis, 421 South Terminal Station, Boston; president Old Colony Railroad Co.

A. I. M. E.—W. E. C. Eustis, 131 State Street, Boston.

A. S. M. E.—Ira N. Hollis, Worcester, president, Worcester Polytechnic Institute.

A. I. E. E.—C. L. Edgar, 70 State Street, Boston; president and general manager, Edison Electric Illuminating Co. of Boston.

A. C. S.—A. D. Little, 93 Broad Street, Boston; president, A. D. Little (Inc.).

Michigan:

A. S. C. E.—G. S. Williams, Cornwell Building, Ann Arbor.

A. I. M. E.—M. M. Duncan, Ishpeming; general manager, Cleveland Cliffs Iron Co.

A. S. M. E.—Alex Dow, 18 Washington Avenue, Detroit; President and general manager, Detroit Edison Co.

A. I. E. E.—H. H. Crowwell, Grand Rapids; president, Michigan Railway Co.

A. C. S.—H. T. Graber, Detroit; chief chemist, Digestive Ferments Co.

Minnesota:

A. S. C. E.—Wm. L. Darling, Railroad Building, St. Paul; chief engineer, Northern Pacific Railway Co.

A. I. M. E.—H. V. Winchell, 826 First National-Soo Building, Minneapolis.

A. S. M. E.—J. J. Flather, Minneapolis; professor of mechanical engineering, University of Minnesota.

A. I. E. E. Wm. N. Ryerson, Duluth; general manager, Great Northern Power Co.

A. C. S.—G. B. Frankforter, Minneapolis; professor of chemistry, dean school of chemistry, University of Minnesota.

Mississippi:

A. S. C. E.—M. L. Lynch, 425 Hamilton Avenue, Jackson.

A. I. M. E.—No resident member.

A. S. M. E.—R. C. Carpenter, Agricultural College; professor of mechanical engineering.

A. I. E. E.—J. T. Robertson, 503 First National Bank Building, Vicksburg; secretary, Mississippi Inspection & Advisory Rating Co.

A. C. S.—Wm. F. Hand, Agricultural College; professor, chemistry, Mississippi Agricultural Mechanical College.

Missouri:

A. S. C. E.—Daniel Bontecou, 502 Dwight Building, Kansas City.

A. I. M. E.—P. N. Moore, 611 Merchants-Laclede Building, St. Louis.

A. S. M. E.—E. Flad, DeMenil Building, St. Louis.

A. I. E. E.—Chas. S. Ruffner, 412 Star Building, St. Louis; president, Mississippi River Power Distributing Co. et al.

A. C. S.—L. F. Nickell, St. Louis; assistant professor chemistry, Washington University.

Montana:

A. S. C. E.—Eugene Carroll, Butte; vice president and general manager, Butte Water Co.

A. I. M. E.—J. L. Bruce, Box 1708, Butte; manager, Butte & Superior Copper Co.

A. S. M. E.—C. V. Nordberg, 305 Electrical Building, Butte; Nordberg Manufacturing Co.

A. I. E. E.—M. H. Gerry, jr., Helena; president, Engineering Corporation.

Nebraska:

A. S. C. E.—Elliot Holbrook, 1011 Union Pacific Building, Omaha; Southern Pacific Co.

A. I. M. E.—Walter T. Page, Omaha; manager, Omaha plant, American Smelting & Refining Co.

A. S. M. E.—Wm. R. McKeen, 1222 Webster Avenue, Omaha; president, McKeen Motor Car Co.

A. I. E. E.—H. A. Holdredge, Omaha; general manager, Omaha Electric Light & Power Co.

A. C. S.—C. F. Crowley, Fourteenth and Davenport Streets, Omaha; professor of chemistry, Creighton University.

Nevada:

A. S. C. E.—W. T. Gould, Reno; Nevada-California-Oregon Railway.

A. I. M. E.—W. E. Trent, Reno; Trent Engineering Co.

A. S. M. E.—James G. Scrugham, Reno; dean, engineering college, University of Nevada.

A. I. E. E.—W. K. Freudenberger, Box 263, Carson City, chief engineer, public service and railroad commissioners of Nevada.

A. C. S.—Maxwell Adams, Reno; professor of chemistry, University of Nevada.

New Hampshire:

A. S. C. E.—Robert Fletcher, Hanover; director and professor of engineering, Thaylor School of Engineering.

A. I. M. E.—H. R. Batcheller, Box 21 Washington.

A. S. M. E.—Thomas W. Fry, Claremont; secretary Sullivan Machinery Co.

A. I. E. E.—J. Brodie Smith, 46 Hanover Street, Manchester; vice president and general manager Manchester Traction Light & Power Co.

A. C. S.—Hugh K. Moore, Berlin; chief chemist research laboratory, Berlin Mills Co.

New Jersey:

A. S. C. E.—Morris R. Sherrerd, City Hall, Newark; chief engineer Department Public Works.

A. I. M. E.—B. F. Cresson, jr., 75 Montgomery street, Jersey City; chief engineer New Jersey State Board Commerce and Navigation.

A. S. M. E.—H. L. Gantt, 2905 Singer Building, New York City.

A. I. E. E.—Farley Osgood, 759 Broad Street, Newark; assistant general manager Public Service Electric Co.

A. C. S.—H. S. Miner, Gloucester; chief chemist Welsbach Light Co., near Camden.

New Mexico:

A. S. C. E.—O. H. B. Turner, Raton; chief engineer St. Louis, Rocky Mountain & Pacific Co.

A. I. M. E.—Stephen O. Andros, Room 5, First National Bank Building, Albuquerque.

A. S. M. E.—L. J. Charles, Elephant Butte; civil engineer, United States Reclamation Service.

A. I. E. E.—J. L. Brenneman, Albuquerque; professor physical and electrical engineering, University of New Mexico.

A. C. S.—John D. Clark, Albuquerque; professor chemistry, University of New Mexico.

New York:

W. M. Rose, secretary, 43 Exchange Place, New York.

A. S. C. E.—James G. White, 43 Exchange Place, New York City; president J. G. White & Co.

A. I. M. E.—Chas. F. Rand, 71 Broadway, New York City; Spanish-American Iron Co.

A. S. M. E.—W. H. Marshall, 30 Church Street, New York City; president American Locomotive Co.

A. I. E. E.—Wm. McClellan, 141 Broadway, New York.

A. C. S.—T. B. Wagner, 17 Battery Place, New York City; manager Corn Products Refining Co.

North Carolina:

A. S. C. E.—J. L. Ludlow, Board of Trade Building, Winston-Salem; consulting, municipal, sanitary, and hydraulic engineer.

A. I. M. E.—Joseph H. Pratt, Chapel Hill; State geologist.

A. S. M. E.—Wm. S. Lee, Mercantile Building, Charlotte; vice president and chief engineer Southern Power Co.

A. I. E. E. Chas. I. Burkholder, Mercantile Building, Charlotte; general manager Southern Power Co.

A. C. S.—F. P. Venable, Chapel Hill; professor of chemistry, University of North Carolina.

North Dakota:

A. S. C. E.—T. R. Atkinson, City Hall, Bismarck; city engineer.

A. I. M. E.—Dean E J. Babcock, University of North Dakota; Grand Forks.

A. S. M. E.—Calvin H. Crouch, 513 South Sixth Street, Grand Forks; dean college of mechanical and electrical engineering, University of North Dakota.

A. I. E. E.—John F. Stevens, Box 1242, University; assistant professor of electric engineering, University of North Dakota.

A. C. S.—Edwin F. Ladd, Fargo; president North Dakota Agriculture College.

Ohio:

A. S. C. E.—Chester W. Larner, 7000 Central Avenue, Cleveland; hydrographic engineer Wellman-Seaver-Morgan Co.

A. I. M. E.—Chas. S. Robinson, Youngstown; second vice president Youngstown Sheet & Tube Co.

A. S. M. E.—Frank A. Scott, 5701 Carnegie Avenue, Cleveland; vice president The Warner & Swasey Co.

A. I. E. E.—Samuel G. McMeen, 1003 Huntington Bank Building, Columbus; president Ohio State Telephone Co.

A. C. S.—James R. Withrow, Columbus; professor of industrial chemistry, Ohio State University.

Oklahoma:

A. S. C. E.—H. V. Hinckley, 1018 North Harvey Street, Oklahoma City.

A. I. M. E.—M. M. Valerius, 319 Clinton Building, Tulsa; Valerius, McNutt & Hughes.

A. S. M. E.—J. P. Fisher, Bartleville.

A. I. E. E.—H. V. Bozell, Norman; director school of electrical engineering, University of Oklahoma.

A. C. S.—Edwin DeBarr, Norman; professor of chemistry, University of Oklahoma.

Oregon:

A. S. C. E.—Geo. C. Mason, Worcester Building, Portland; vice president Hurley-Mason Co.

A. I. M. E.—A. M. Swartley, Corvallis; bureau of mines and geology.

A. S. M. E.—Bert C. Ball, Portland; president and manager Willamette Iron & Steel Works.

A. I. E. E.—O. B. Coldwell, 602 Electric Building, Portland; general superintendent Portland Railway Light & Power Co.

A. C. S.—O. F. Stafford, Eugene; professor of chemistry and director chemical laboratories, University of Oregon.

Pennsylvania:

A. S. C. E.—George S. Davison, Frick Annex Building, Pittsburgh; president Gulf Refining Co.

A. I. M. E—Vance C. McCormick, Bergner Building, Harrisburg; publisher, trustee for estates, etc.

A. S. M. E.—Julian Kennedy, 1217 Bessemer Building, Pittsburgh.

A. I. E. E.—Paul Spencer, 1401 Arch Street, Philadelphia; electrical engineer, United Gas & Improvement Co.

A. C. S.—R. F. Bacon, Pittsburgh; director Mellon institute of industrial research, University of Pittsburgh.

Rhode Island:

A. I. M. E.—Walter M. Saunders, 184 Whittier Avenue, Providence; Saunders & Franklin.

A. S. M. E.—Henry D. Sharpe, Providence; treasurer Brown & Sharpe Manufacturing Co.

A. I. E. E.—L. W. Downes, Providence; vice president and general manager D. & W. Fuse Co.

A. C. S.—J. E. Bucher, Providence; professor of chemistry, Brown University.

South Carolina:

A. S. C. E.—John McNeal, City Hall, Columbia; city engineer.

A. I. M. E.—H. L. Scaife, Clinton; moved to Pennsylvania; lawyer and manager of mining companies.

A. S. M. E.—J. L. Coker, jr., Hartsville; vice president Carolina Fiber Co.

A. I. E. E.—W. M. Riggs, Clemson College; president Clemson Agricultural College.

A. C. S.—R. N. Brackett, Clemson College; director of chemistry department, Clemson Agricultural College.

South Dakota:

A. S. C. E.—Bruce C. Yates, 113 Durango Street, Lead; assistant superintendent Homestake Mining Co.

A. I. M. E.—Allan J. Clark, Lead; metallurgist, Homestake Mining Co.

A. S. M. E.—M. W. Davidson, Vermillion; professor of mining engineering, University of South Dakota.

A. I. E. E.—B. B. Brackett, Brookings; professor of electrical engineering, South Dakota State College.

A. C. S.—William J. Sharwood, Lead; metallurgy and chemistry, Homestake Mining Co.

Tennessee:

A. S. C. E.—William W. Carson, 1705 Clinch Avenue, Knoxville; professor of chemical engineering, University of Tennessee.

A. I. M. E.—A. A. Blow, Holston Bank Building, Knoxville; president Carolina Copper Co.

A. S. M. E.—Newell Sanders, Chattanooga; Newell Sanders Plow Co.

A. I. M. E.—F. G. Proutt, Memphis.

A. C. S.—W. H. Hollinshead, Vanderbilt University, Nashville.

Texas:

A. S. C. E.—John B. Hawley, F. & M. Bank Building, Fort Worth.

A. I. M. E.—Arthur J. McQuatters, Mills Building, El Paso; Wells-Fargo Express.

A. S. M. E.—W. B. Tuttle, 305 East Houston Street, San Antonio; vice president San Antonio Traction Co. and San Antonio Gas & Electric Co.

A. I. E. E.—Fred A. Jones, Sumpter Building, Dallas.

A. C. S.—George W. Gray, Houston; chairman manufacturing committee, The Texas Co.

Utah:

A. S. C. E.—A. F. Parker, 2482 Washington Avenue, Ogden.

A. I. M. E.—Lafayette Hanchett, National Copper Bank, Salt Lake City; director National Copper Bank and Bankers' Trust Co.

A. S. M. E.—William Wraith, 618 Kearns Building, Salt Lake City; general manager International Smelting Co.

A. I. E. E.—Markham Cheever, 523 Kearns Building, Salt Lake City; chief engineer, Utah Power & Light Co.

A. C. S.—William C. Ebaugh, 809 Kearns Building, Salt Lake City; United States Smelting Co.

Vermont:

A. I. M. E.—C. B. Hollis, Randolph; general superintendent Eastern Talc Co.

A. S. M. E.—J. Hartness, Springfield; president Jones & Lamson Machine Co.

A. I. E. E.—B. T. Burt, Rutland; vice president and general manager Rutland Railway, Light & Power Co.

A. C. S.—G. H. Burrows, Burlington; professor of chemistry, University of Vermont.

Virginia:

A. S. C. E.—E. T. D. Myers, jr., 1201 Mutual Building, Richmond; director Commonwealth Coal Corporation.

A. I. M. E. Frank U. Humbert, Low Moor; manager mines, Low Moor Mining Co.

A. S. M. E.—W. D. Mount, Saltville; general manager Mathieson Alkali Works.

A. I. E. E.—Walter S. Rodman, University; professor electrical engineering, University of Virginia.

A. C. S.—Frank B. Carpenter, 11 South Twelfth Street, Richmond; chief chemist Virginia-Carolina Chemical Co.

Washington:

A. S. C. E.—A. O. Powell, 404 Central Building, Seattle.

A. I. M. E.—J. C. Ralston, 2421 West Mission Avenue, Spokane; vice president Pacific Coast Pipe Co.

A. S. M. E.—James V. Paterson, 1025 Boylston Avenue north, Seattle.

Washington—Continued.

A. I. E. E.—John Harisberger, Electric Bldg., Seventh and Olive Streets, Seattle; general superintendent light and power department, Puget Sound Traction, Light & Power Co.

A. C. S.—H. K. Benson, Seattle; professor of industrial chemistry, director bureau industrial research, University of Washington.

West Virginia:

A. S. C. E.—A. M. Scott, Charleston.

A. I. M. E.—I. C. White, 141 Willey Street, Morgantown; State geologist.

A. S. M. E.—Charles E. Ward, Box 647, Charleston; president Charles Ward Engineering Works.

A. I. E. E.—H. S. Sands, 47 Eleventh Street, Wheeling; president H. S. Sands Electric & Manufacturing Co.

A. C. S.—A. R. Whitehill, Morgantown; professor of chemistry, West Virginia University.

Wisconsin:

A. S. C. E.—D. W. Mead, 530 State Street, Madison; professor hydraulic engineering, University of Wisconsin.

A. I. M. E.—F. W. O'Neill, Milwaukee; sales manager, Nordberg Manufacturing Co.

A. S. M. E.—L. E. Strothman, Milwaukee; department manager, Allis-Chalmers Manufacturing Co.

A. I. E. E.—C. H. Kelsey, First National Bank Building, Milwaukee.

A. C. S.—C. F. Burgess, Madison; president C. F. Burgess Laboratories.

Wyoming:

A. S. C. E.—Edward Gillette, Sheridan.

A. I. M. E.—W. D. Waltman, Casper; general manager Franco-Wyoming Oil Co.

A. S. M. E.—E. G. Hoefer, Laramie; head department of mechanical and electrical engineering, University of Wyoming.

A. I. E. E.—P. N. Nunn, Casper; president Wyoming Electric Co.

A. C. S.—R. B. Moudy, Laramie; State chemist, professor of chemistry, University of Wyoming.

The form of questionnaire is as follows:

[Sample inventory.]

Industrial inventory, 1916, for Army and Navy.

A strictly confidential, nonpartisan, nonpolitical, and wholly patriotic inventory of our country's manufacturing and producing resources for the benefit of the War and Navy Departments. The information given upon this form is to be used in effecting the industrial organization necessary to the plans for national defense. The value of this patriotic work can best be insured by making this report complete in every detail.

Instructions.—(1) Inquiries that are followed by a question mark (?) should be answered "yes" or "no." If additional space is required for any of the questions, use back of schedule, and the printed "supplemental" sheets, if necessary, designating the answers by numbers corresponding to those in this schedule. *Every question should be answered.* If not applicable, write word "none." (2) Section I. "Business and administrative" may be answered for the company as a whole, but separate reports, under the remaining sections of the schedule, should be made for all plants having different locations.

I. BUSINESS AND ADMINISTRATIVE.

1. Name of establishment, X Y Z Co.
2. Character of organization, corporation.
3. Post-office address of general office, Market Street, San Francisco, Calif.
4. Date business was established, 1890.
5. Does this report and attached schedules cover all the business of this company and its subsidiaries? Yes.
6. Officers—

Name.	Age.	American citizen.	If not American citizen, country of birth.	Name.	Age.	American citizen.	If not American citizen, country of birth.
John Doe, president	38	Yes		John Doe, secretary	38	Yes	
Richard Roe, vice president.	42	Yes		Richard Roe, chief engineer.	42	No	England.
John Smith, general manager.	40	Yes		John Jones, works manager.	35	Yes	
John Jones, treasurer	35	Yes.					

7. Owners or principal stockholders—

Name.	Address.		American citizen.	If not American citizen, country of birth.
	City.	State.		
John Doe	San Francisco	California	Yes.	
Richard Roe	do	do	Yes.	
John Smith	do	do	Yes.	
John Jones	do	do	Yes.	

8. Directors—

Name.	Address.		American citizen.	If not American citizen, country of birth.
	City.	State.		
John Doe, chairman				
Richard Roe				
John Smith				
John Jones				

9. Representatives abroad (names, business relation, and location), none.

10. Approximate value of physical plant $2,500,000.

11. Principal bank or banks with which business is done (names and locations), First National Bank of San Francisco.

II. PLANT.

1. (*a*) Location of plant, San Francisco, Calif. Occupies block bounded by Market Street, Broadway, and Sixth Avenue. (*b*) Number of buildings, 4. (*c*) Are buildings owned or rented? Owned.

2. Plant surroundings, open but not isolated.

3. Population of city, 100,000.

4. City map attached? Yes.

5. Blue prints attached (*a*) ground plan with building locations? Yes. (*b*) Floor plans? Yes.

6. Total ground area, 300,000 square feet.

7. Ground area unoccupied available for expansion, 180,000 square feet.

8. Building construction, concrete.

9. Number of stories, 2.

10. Insurance rate, $0.45.

11. Floor space, 210,000 square feet.

12. Approximate carrying capacity of floors per square foot, 2,000 pounds.

13. (*a*) Can stories be added? No.

14. Company offices in plan or separate? Separate.

15. Description of fire protection standpipes with hose on each floor; automatic sprinkler system with tanks on roof.

16. Sprinkler system, automatic.

17. (*a*) Heat—developed in plant? Yes. (*b*) Light—developed in plant? No. Purchased, electric. (*c*) Water supply, private; outside in case of need.

18. (*a*) Power developed in plant, electric. (*b*) Power now operating, 2,500 horsepower. (*c*) Maximum capacity, 3,000 horsepower.

19. Can plant be operated at night? Yes.

20. Elevators—(*a*) Number of freight, 6. (*b*) Capacity of largest, 6,000 pounds. (*c*) Platform of largest, length, 15 feet; width, 10 feet.

21. (*a*) Are facilities ample for feeding employees? None.

22. (*a*) Are facilities ample for housing employees? None.

23. Wash rooms? Yes.

24. Lockers for employees? Yes.

25. (*a*) Postal or Western Union office in plant? Western Union. (*b*) Number of telegraph operators, 1. (*c*) How many are not American citizens? None.

26. (*a*) Telephone switchboard in plant? Yes. (*b*) Number of telephone operators, 2. (*c*) How many are not American citizens? None. (*d*) Number of departmental extensions, none. (*e*) Number of trunk lines to outside, 2.

27. Auto call or other signaling system in plant? No.

28. Pneumatic tubes between departments? No.

III. MANUFACTURE AND PRODUCTION.

1. Normal yearly slack season, from June 1 to September 1.

2. Approximate percentage of machine and tool equipment idle in slack season, 20 per cent.

3. Is there a planning or routing department in factory? Yes.

4. To what limits in precision in machine work does factory operate? To one one-thousandth of an inch.

5. Principal materials used and from whom purchased:

Kind.	Unit of measure (tons, etc.).	Approximate amount used annually.	Name (optional).	Location.
Pig iron	Tons	100,000		Chicago, Ill.
Coal	do	500		Pittsburgh, Pa.
Coke	do	200		Do.
Foundry sand	Cans	30		Do.
Special alloys	Tons	3		Do.
Tool steel	do	1		Do.
Billets and shops	do	30,000		Do.
Copper, zinc, etc., in varying amounts				

6. Principal products manufactured:

Kind.	Unit of measure (tons, etc.).	Approximate amount manufactured annually.	Approximate proportion exported.	To what countries (optional).
Steel castings	Tons	50,000		
Mine machinery	do	30,000		
Drop forgings	do	20,000		
Nuts, bolts, etc	do	10,000		

7. How are products marketed—(*a*) direct? Yes. (*b*) Jobbers? Yes. (*c*) Wholesale? No. (*d*) Retail? No.

8. Catalogue of products attached? Yes (set of Bulletins).

9. (*a*) Are branch offices or depots maintained for distributing purposes? Yes. (*b*) If so, where? Chicago, Birmingham, Salt Lake, San Francisco.

10. (*a*) Have Army and Navy goods been supplied to the Government within past two years? Yes. If so, in what kinds and in what quantities:

(*b*) For U. S. Government—		(*c*) For foreign Governments—	
Principal kinds.	Approximate quantities.	Principal kinds.	Approximate quantities.
Package handling portable elevator at Brooklyn Navy Yard.	1		
De Mayo coaling plant, same location.	1		

11. Has plant facilities for construction of jigs and tools? No.

12. Has company a Government contract department? No.

IV. LABOR.

1. (*a*) Is labor easy to obtain? Yes. (*b*) If factory was enlarged? Yes. (*c*) Union shop? No.

2. General labor conditions: (*a*) Any labor trouble within past year? None.

3. Number clerical and office force—(*a*) Total, 100. (*b*) Men, 10. (*c*) Women, 90.

4. (*a*) Number of men in shop (busy season), 1,000. (*b*) Approximate number skilled, 800. (*c*) Approximate number unskilled, 200.

5. Number of toolmakers, 50.

6. (*a*) Number of women in shop (busy season), 200. (*b*) On what lines work, light assembly.

7. In which departments, if absolutely necessary, can women replace men, and in what numbers? Light machine department; about 100 men could be so replaced.

8. General system of pay—piecework or hour? Hour.

9. (*a*) Number of hours per day or per shift, 10. (*b*) Number of shifts per day, 1. (*c*) Number of hours per week for each shift, 60.

10. Is overtime work done willingly? No.

11. Is night work possible? Yes.

12. Approximate percentage of employees that are not American citizens, 13 per cent.

V. TRANSPORTATION.

1. (*a*) Railroad shipping point, if outside of plant, ———. (*b*) Trucking distance, ———. (c) Kind and quality of street surface en route, ———.

2. Number of trucks owned, horse-drawn,———; motor, 6.

3. Railroad trunk lines accessible, Southern Pacific; Union Pacific.

4. (*a*) Shipping facilities inside of plant? Yes. (*b*) Car capacity of sidings, 50. (*c*) Switching by railroad or self? Self.

5. Car capacity of sidings adjacent to plant, 1,000.

6. (*a*) Shipping facilities by water? Yes. (*b*) Docks, length in running feet, 1,000. (*c*) Maximum draft of vessels which can reach docks, 12 feet. (*d*) Trucking distance between plant and docks, one-eighth mile. (*e*) Kind and quality of street surface en route, wooden block. (*f*) Crane capacity on docks, 75 tons.

VI. POSSIBLE FUTURE ARRANGEMENTS.

1. Would consider bidding upon regular United States Army and Navy contracts in time of peace? Yes.

2. Would consider accepting United States Army and Navy business in time of war on cost plus reasonable profit basis? Yes.

3. Would consider accepting "Minimum annual educational order" (see Clause A below)? Yes.

4. Would consider accepting payment in accordance Clause B? Yes.

5. Would favor the enrolling of skilled labor in "Industrial Reserve" (see Clause C)? Yes.

Clause A.—Minimum order for annual production of Army and Navy goods will be accepted with the understanding that such order will be restricted to that product for which the manufacturer's equipment is best fitted; also, that such order shall be for only such a quantity of product as will insure familiarity with the work upon the part of the manufacturer's organization. The manufacturer agrees that this minimum annual educational order shall be put through the factory in regular course and in such manner that foremen and those holding positions of responsibility shall become familiar with the peculiarities incident to the manufacture of these goods. In event of war the manufacturer will be expected to concentrate upon this same product, and it is essential, therefore, that his entire organization, including purchasing, manufacturing, inspection, shipping, engineering, cost keeping, and administrative departments, be made familiar with the work Minimum orders will not be of sufficient quantities to interfere with manufacturer's regular production.

Clause B.—It is proposed that payments for "Minimum annual orders," covered in Clause A, shall be made upon the basis of the actual cost of production, inclusive of all special tools, jigs, etc., plus a reasonable profit. In case special jigs, tools, gauges, or fittings are necessary for the production of these goods, a minimum supply shall be kept on hand, and if they can be made in the plant, the engineering or designing department shall maintain at all times corrected drawings from which the shop may, upon short notice, construct the necessary equipment for quantity production.

Clause C.—In war as now waged the industrial force has become quite as important as the fighting army. Skilled mechanics in all lines of production work must be kept from enlistment in the Army and must be retained in the factories, mills, and mines for the production of munitions. It is essential, therefore, that the names of these skilled workmen be listed and that the men themselves be enrolled in the Industrial Reserve. It is proposed that a button or other distinguishing mark will be supplied by the Government, in the event of war, to skilled workmen enrolled in the Industrial Reserve, and such enrollment will be considered to carry with it honors equal to enrollment in the fighting army. It is also proposed that a Government card will be issued to each man enlisted.

VII. INVENTORY, MANUFACTURING AND PRODUCING EQUIPMENT.

Describe in such detail as will permit of intelligent decision as to work for which equipment is best fitted. Summarize classes of tools and types of machinery or producing equipment.

Foundry: One 20-ton cupola; one 50-ton cupola; one 15-ton converter; one 20-pot crucible furnace for brass and bronze, crown capacity 25 tons: well-equipped core room.

Forge shop: Thirty 300-pound hammers; one 25-ton steam hammer; five 5-ton steam hammers; 25 anvils and forges.

Machine shop: Sixteen engine lathes, 12-inch and under; 10 engine lathes, over 12-inch; 50 automatic lathes, 6-inch and 8-inch; 3 planers, 36-inch; 1 planer, 60-inch; 5 milling machines, 12-inch; 12 milling machines, 10-inch; 25 drill presses, 22-inch; 4 radial drills, 5-foot; 8 shapers, 20-inch; 6 multiple-spindle drills, 10 spindles; 5 boring and turning mills, 4-foot; 2 boring and turning mills, 8-foot.

Well-equipped tool room; usual amount of grinders and other auxiliary machine tools.

1. (*a*) Is there a chemical testing laboratory? Yes. (*b*) Physical laboratory? Yes. (c) What, if any, other special equipment for scientific testing? Apparatus for metallographic examinations; complete hydrometer equipped in shops and laboratory.

VIII. FIELD NOTES.

(This page to be used by board representative.)

This firm is up to date and very willing to cooperate in every way in carrying out the idea of preparedness.

Name and title of official giving the information for this report. John Doe.

Report secured by John Brown. Date, June 6, 1916. Member of American Institute of Electrical Engineers.

Received and transmitted by Thomas Jones, State director.

SOME OF THE GUESTS AT A LUNCHEON GIVEN AT DELMONICO'S, TUESDAY, MARCH 14, 1916, BY HOWARD E. COFFIN, CHAIRMAN OF THE COMMITTEE ON INDUSTRIAL PREPAREDNESS OF THE NAVAL CONSULTING BOARD OF THE UNITED STATES.

Ogden Reid, of the New York Tribune; George McAneny, of the New York Times; Charles H .Grasty, of the New York Times; Arthur Page, of World's Work; Col. W. C. Church, of the Army and Navy Journal; Howard E. Coffin, chairman of committee; William L. Saunders, second vice chairman of the Naval Consulting Board; Dr. Albert Shaw of the American Review of Reviews; W. S. Gifford, supervising director, Committee on Industrial Preparedness; M. N. Stiles, of the Associated Press; Henry C. Bate, of the New York Press; Deltus M. Edwards, of the New York Herald; Milton Bronner, of the Scripps-MacRae League; Courtland Smith, of the American Press Association; William S. Woods, of the Literary Digest; William Shillaber, jr., of the New York Globe; Dr. Edward A. Rumely, of the New York Evening Mail; Ernest Abbott, of the Outlook; Grosvenor B. Clarkson; Allan Dawson, of the New York Globe; William Menkel, of the American Review of Reviews; Edwin A. Slosson, of the Independent; Bascom Little, president of the Cleveland Chamber of Commerce and chairman of the National Defense Committee of the Chamber of Commerce of the United States; Charles A. Munn, of the Scientific American; Henry Souther, of the Henry Souther Engineering Co.; Herbert L. Bridgman, of the Brooklyn Standard-Union; Arthur Brisbane, of the New York American; Henry James Forman, of Collier's Weekly; Herbert F. Gunnison, of the Brooklyn Eagle; Herbert S. Houston, of Doubleday, Page & Co., president of the Associated Advertising Clubs of the World; Roy W. Howard, president of the United Press Associations; Waldemar Kaempffert, of the Popular Science Monthly; Stoddard King, of Harper's Weekly; Charles M. Lincoln, of the New York World; George Smith, of the New York Sun; Carl Snyder; F. J. Splitstone, of Leslie's Weekly; Nathan Straus, jr., of Puck; J. Bernard Walker, of the Scientific American.

Rules and Regulations of the Naval Consulting Board of the United States.

PREAMBLE.

The Naval Consulting Board was formed in 1916 by the Secretary of the Navy by the appointment of Mr. Thomas A. Edison as its head, one personal nominee by Mr. Edison, and two delegates selected from and representing each of the following-named technical societies: American Chemical Society, American Institute of Electrical Engineers, American Mathematical Society, American Society of Civil Engineers, American Aeronautical Society, Inventors' Guild, American Society of Automobile Engineers, American Institute of Mining Engineers, American Electro-Chemical Society, American Society of Mechanical Engineers, American Society of Aeronautic Engineers, and in an act of Congress passed in 1916 this board was legalized.

The board has adopted the following set of rules and regulations for its continuance and government, subject to the approval of the Secretary of the Navy.

I. NAME.

The name of the board shall be "The Naval Consulting Board of the United States."

II. PURPOSE.

The purpose of this board shall be to assist the United States Navy Department in any manner that it may, by supplying technical advice when called upon by any bureau or board of the department organized by law or appointed by the Secretary of the Navy, and to bring to the attention of the Navy Department through the proper channels such technical matters as it considers may have value to the Naval Service, with suggestions and recommendations relating thereto.

III. MEMBERSHIP.

1. The tenure of office of each member of this board shall be for such a term as, in the judgment of the Secretary of the Navy and the society which nominated him, his services are desirable.

2. The board may at any time by a vote of two-thirds of its full membership request the Secretary to remove from the board any member thereof.

3. If any member retires from the board for any reason, the society which delegated him or his predecessor shall nominate his successor, who upon approval of and appointment by the Secretary of the Navy shall become a member of the board.

4. Any person hereafter appointed to membership on this board shall be a citizen of the United States of not less than five years' standing.

IV. OFFICERS.

1. The officers of the board shall be:

   Thomas A. Edison, president.
   A vice president.
   A chairman of the board.
   A secretary of the board.

The three latter shall be elected annually by written ballot by the board from among its members at its annual meeting, which shall take place in

March. Due notices of such election shall be sent to each member of the board at least 10 days in advance of such annual meeting.

2. The terms of office of the vice president, chairman, and secretary shall be for one year.

V. MEETINGS.

1. Regular meetings of the board shall be held at intervals of one month, excepting that there shall be no regular meetings during the monts of July and August, and special meetings shall be called by the secretary of the board, with at least five days' notice, upon request of the Secretary of the Navy or the president or the vice president or the chairman or any five members of the board; the time, date, and place of the meeting to be arranged by the secretary of the board in conference with those officers or members at whose request the secretary called the meeting.

2. The chairman shall preside at all meetings of the board, and in the event of his absence the vice president, if present, otherwise any member of the board may be chosen as chairman pro tempore by a majority of those present.

3. A quorum shall consist of 10 members.

4. A member absent from a meeting may record a vote, aye or nay, by mail or telegram, but only for or against a resolution which shall have been referred to him by mail five days in advance of the meeting.

VI. COMMITTEES.

1. The membership of this board shall subdivide itself into technical committees at its discretion.

2. Special or temporary committees may be appointed from time to time by the chairman of the board unless the board elects to name such committees by ballot.

3. Any committeeman may request the cooperation of any individual or individuals not members of the board at any committee meeting for conference.

VII. FUNCTIONS.

1. All matters submitted to the board by the Secretary of the Navy shall be communicated to all members by the secretary of the board, who shall forward the replies to the appropriate committees to be collated and reported to the full board with recommendations for its action thereon.

2. The board, in addition to the consideration of such matters as may be referred to it by the Navy Department or any of its bureaus or boards, may of its own initiative, or through the initiative of any of its committees, take up any matter which it or such committee may deem advisable and in the interests of the Naval Service, formulate reports thereon and submit same through the proper channels to the Navy Department for its consideration.

VIII. RECORDS.

1. The proceedings of this board and of the committees of the board shall be recorded and be regarded as confidential, and no part of the same shall be made public except by the authority of the board.

2. The minutes of meetings of the board shall consist of actions taken by the board and reports of committees, which shall be submitted in writing and after action by the board shall be filed.

IX. AMENDMENTS.

No amendment to these rules and regulations shall be made except in accordance with the following procedure:

(*a*) Amendments to these rules and regulations may be proposed at any regular meeting, and shall be voted upon at the next regular meeting of the board.

(*b*) The secretary of the board shall send to each member a copy of any proposed amendment at least two weeks prior to the meeting at which time it is to be voted upon.

(*c*) It shall require a favorable two-thirds vote of the entire membership of the board, expressed either verbally or in writing, to adopt any amendment to these rules and regulations.

(*d*) No amendment shall be effective until it shall have been approved by the Secretary of the Navy.

LETTER SENT BY SECRETARY OF THE NAVY JOSEPHUS DANIELS TO MR. THOMAS A. EDISON.

SEPTEMBER 19, 1916.

SIR: In pursuance of authority conferred by the act of Congress entitled "An act making appropriations for the naval service for the fiscal year ending June thirtieth, nineteen hundred and seventeen, and for other purposes," approved August 29, 1916, a board, legally designated the "Naval Consulting Board," is hereby constituted and appointed for the purpose of consulting and making recommendations to the department concerning matters affecting the Naval Establishment.

The members of such board are, as you are aware, not to receive any salary or compensation, their services being voluntary.

Provision is made by the law for the expenses incurred by and in connection with the board, and appropriate instructions will be issued to the Paymaster General of the Navy relative to the defraying of such expenses.

The board will meet at the Navy Department, Washington, D. C., on Tuesday, the 19th instant, for the purpose of organization, and will meet thereafter when convened by the department, and at such other times and places as may be specified by you.

The board will prescribe rules and regulations for its own government, furnishing the department a copy thereof, with report, when organization shall have been effected.

It is desired that all matters submitted to or considered by the board be regarded and treated as strictly confidential, unless and until this restriction shall be removed by the department.

Sincerely, yours.

JOSEPHUS DANIELS.

THE PRESIDENT OF THE NAVAL CONSULTING BOARD,
Navy Department, Washington, D. C.

LETTER SENT BY SECRETARY OF THE NAVY JOSEPHUS DANIELS TO BOARD MEMBERS.

SEPTEMBER 19, 1916.

SIR: In pursuance of authority conferred by the act of Congress entitled "An act making appropriations for the naval service for the fiscal year ending June thirtieth, nineteen hundred and seventeen, and for other purposes," approved

August 29, 1916, a board, legally designated the "Naval Consulting Board," is hereby constituted and appointed for the purpose of consulting and making recommendations to the department concerning matters affecting the Naval Establishment. Being already assured that you will accept duty in such capacity, I hereby designate you a member of the Naval Consulting Board.

Sincerely, yours,

JOSEPHUS DANIELS.

OATH OF OFFICE.

Having been appointed a member of the Naval Consulting Board, I, ——— ———, do solemnly swear (or affirm) that I will support and defend the Constitution of the United States against all enemies, foreign and domestic; that I will bear true faith and allegiance to the same; that I take this obligation freely, without any mental reservation or purpose of evasion; and that I will well and faithfully discharge the duties of the office on which I am about to enter. So help me God.

——— ———.

State of ———, county of ———, *ss:*
Sworn to and subscribed before me this ——— day of ———, 19—.

——— ———.

THE SUBMARINE AND KINDRED PROBLEMS.

[Bulletin No. 1, July 14, 1917. Naval Consulting Board of the United States.]

The thousands of suggestions and plans presented to the Naval Consulting Board for assisting the Government in the present emergency indicate the patriotic fervor of the mass of our citizens.

The board makes a careful examination of every proposal presented. To facilitate this work, by suggesting the elimination of impractical ideas, the board calls to the attention of those who desire to assist it some of the popular misconceptions as to certain fundamental principles which are most frequently misunderstood by the layman.

A careful consideration of the following statements will greatly simplify the work of the Naval Consulting Board.

ELECTRO MAGNETS AND MAGNETISM.

The electro magnet, the magnetic needle, permanent magnets, and magnetism have been carefully studied for many years; and the laws governing their application may be found in any book on the subject.

Although these laws are generally known, and applied in a practical manner, in a multitude of devices in common use, even the man of wide exeprience will be astonished at the limited range of practical effect of electro magnets of large size. For instance, the magnets used in our manufacturing plants for lifting heavy masses of iron or steel are designed to exercise maximum magnetic effect, and for operation require a very considerable amount of electrical energy; yet a magnet which can lift 20 tons, when placed in contact with an iron plate of that weight, will not lift a 2-inch cube of iron or steel if separated from it a distance of 2 feet. Therefore proposed devices which depend on the attractive power of magnets for their operation in deflecting or arresting torpedoes, mines, or submarines must be governed by the simple laws of magnetism. A torpedo weighing approximately 2,500 pounds, and traveling at a speed of 25 to 45 miles an hour, will not be deflected to any practical degree by any known application of magnetism; and it is not believed that an enemy torpedo, mine, or submarine will ever be found in a position to be interfered with effectively by any electro-magnetic means, however powerful.

Electrical Effects in General.

There is a general misconception regarding the "electrification" of water and the atmosphere. There is no known method of "charging the sea with electricity," or "shooting a bomb of electricity," or of "charging the atmosphere with electrocuting current." Suggestions along these lines should show that the writer has made research in the laws governing the application of electrical energy and should contain sufficient proof of their feasibility to insure serious consideration.

On the other hand, applications of the transmission of electrical energy by means of alternating or pulsating currents—as used in wireless systems, for example—belong to a different class of electrical development. Inventive genius is rapidly improving apparatus of this type for the sending and receiving of signals and messages, and the possibility of valuable results in this field is unlimited.

Protection Against Submarine Attack.

This subject, which is occupying the public mind as is no other, divides itself into a number of problems, the most important being the following:

(*a*) Means of discovering the approach of a hostile submarine and locating it so as to permit of prompt action for combating its attack.

(*b*) Protection of cargo-carrying ships by nets, guards, and screens.

(*c*) Protection through decreasing the visibility of vessels.

(*d*) Methods of destroying or blinding a hostile submarine.

Submarines, to operate most effectively, must approach within close range of the vessel which is intended to be torpedoed. The installation of offensive weapons on the merchant marine has increased the necessity for the utmost care being exercised by the submarine commander in remaining unseen by the officers on the vessel to be attacked.

Reports from abroad indicate that in many cases submarines must have remained along certain lanes of travel for periods extending into weeks of waiting with the expectation of torpedoing certain vessels. Under certain favorable conditions, where the waters are less than 200 feet in depth, a submarine might lie at rest on the bottom, and if equipped with sensitive listening devices attempt to detect the approach of a vessel. As soon as this evidence was secured the submarine might come to the surface for a quick observation by means of the periscope and in this manner obtain the proper aim which would be required to register an effective hit.

In case the water is more than 200 feet in depth a submarine must be kept in motion to obtain steerage way in order to hold its proper depth of submergence. This speed may not exceed 4 or 5 miles per hour, but to remain submerged, and at the same time unobserved, the water must be at least 60 feet deep.

The latest type of submarine which is being used abroad has a surface speed of at least 17 knots per hour and a submerged speed of probably less than 10 knots. The superior gunfire from the merchantman which has been properly equipped would make it necessary for the submarine commander to obtain his observations, such as would permit accurate aiming of the torpedo, during the very brief interval of time required to come to the surface for observation through the periscope and to again submerge.

If running near the surface, the periscope might be raised, a quick observation taken, and lowered again within 30 seconds. If, however, the submarine is on the surface and hatches uncovered, from one to four minutes will be required to completely submerge, depending upon circumstances.

A submarine of recent type probably has a total radius of action of as much as 8,000 miles when traveling at a moderate cruising speed of from 10 to 11 knots, and may remain away from its home base for as much as one month, without requiring either fuel or other supplies during this period.

This type of submarine may have as many as three periscopes, two conning towers, and two rapid-fire guns attached to the upper portion of its hull.

The vessel is steered by very efficient gyroscopic compasses, which are unaffected by extraneous magnetic or electrical influences.

A general understanding of the capabilities of the modern submarine for offensive operations will make it easier to appreciate the importance of the three problems which follow:

(A) MEANS FOR DISCOVERY.

The aeroplane.—When the condition of sea and air are favorable, a submarine is readily discernible from an aeroplane flying at a sufficient height even though the submarine be submerged to a considerable depth.

While aeroplanes have thus been used successfully in the English Channel, they are unable to fly far out to sea where the submarines are now most active. Mother ships for carrying and launching aeroplanes might be used in this connection, but there are only a small number of such ships in operation and the construction of others under present conditions is necessarily a slow process.

Various sound-recording devices, intended to locate surface vessels, submarines, and even moving torpedoes, are now being carefully tested. Water is an excellent conductor of sound, and the development and improvement of such apparatus offers a promising field for inventive endeavor to those who possess adequate scientific training and laboratory facilities.

Many devices are suggested which depend upon optical means of detection, such as special forms of telescopes and field glasses to be mounted on ships, or on scouting vessels. Many special forms of searchlights and projectors have been suggested. The fact that a moving torpedo leaves in its wake a stream of air bubbles caused by the exhaust air from its propelling engines, offers, under favorable conditions, one means for discovering the approach of a torpedo. This evidence is, however, difficult to detect in a rough sea or at night, and, furthermore, the bubbles do not reach the surface of the water until after the torpedo has traveled onward a distance of from 50 to 200 feet toward its target.

The dragging of trawls, or nets, by special guard boats, not only with the view of locating submerged submarines but also to sweep up floating and stationary mines, is frequently suggested. Under certain conditions this operation is practicable and effective.

It will be seen that each of the above methods, however useful, has its limitations, and scientists and inventors should apply themselves not only to the task of improving these, but also of finding supplementary methods and devices.

(B) PROTECTION OF CARGO-CARRYING SHIPS BY NETS OR SCREENS.

Many designs of such devices are suggested, and most of them are intended to be attached to the hull of the vessel to be protected. Many other suggestions along these lines, and differing only in some of their minor characteristics from the foregoing, have been received by the board. Up to the present time not one of these proposals involving screens of any kind has received the approval of the Navy Department or of the merchant marine. The principal objections offered to these devices are that they are heavy, difficult to hold in position, unmanageable in a heavy sea, and that they interfere with the speed and with the ability of the vessel to maneuver. The undeniable evidence which has been accumulated during the past few months of submarine activity has demonstrated that the immunity of a vessel to submarine attack is dependent very largely on its speed and also its maneuvering ability. The percentage of vessels having speeds of 15 knots or more which have suffered from submarine attack is very small, while the losses of slow vessels, whose speed is less than that of a submerged submarine, is practically 100 per cent of those attacked. Many of the suggested devices would prevent the launching of lifeboats or rafts from the vessel to be protected. It is barely possible, however, that there may be developed some form of this general plan which will be found practicable. In no other field have so many suggestions or so many duplicate inventions been presented to the board.

(C) PROTECTION THROUGH INVISIBILITY.

The point of lookout on a submarine being close to the water, the position of a vessel at a distance can only be determined by observing its smoke, which floats high in the air. Improved smokeless combustion is therefore desirable. Relative invisibility may also be afforded by methods of painting.

(D) DESTRUCTION AND BLINDING OF THE SUBMARINES.

A rapid-fire gun is effective when the submarine is seen within accurate range of the gun; but the target is so small that it is difficult to hit.

The powerful effect of any submarine explosion on all neighboring bodies provides a simple means of destroying or crippling an undersea boat. Once it has been even approximately located, the setting off of a heavy charge of high explosive well submerged in the vicinity of the submarine will bring about this result.

In certain areas a quantity of heavy, black petroleum, or similar substance, which will float on the surface of the water, has proved an effective means of clouding the optical glass in the periscope's exposed end.

Under favorable conditions of wind and position, many vessels have saved themselves from torpedo attack by the production of a smoke screen. This may be formed either by incomplete combustion of the oil used for fuel by most naval vessels, or it may be created by burning chemicals, such as phosphorus and coal tar, or mixtures in which both of these and other materials are used.

After hiding itself from the submarine in a cloud of dense smoke, the vessel, if possessed of sufficient speed, may be able by a quick maneuver to change her position and escape before the submarine is able to discharge a torpedo.

MINES AND TORPEDOES FOR NAVAL OPERATIONS.

(A) MINES.

Ever since the first use of gunpowder in the prosecution of war, mines and torpedoes have received great attention both from the warrior and the inventor. Mines are either fixed or floating. The fixed or stationary submarine mine is fired by contact, electricity, timing device, or fuse. Such mines, which are extensively used by all navies, are rugged in design and may contain large charges of explosives. They are placed in position by especially equipped mine-laying vessels. Such a mine is provided with an anchoring device.

Floating mines differ from fixed mines in that they are unanchored, and, unless guard boats are at hand to warn friendly vessels of their proximity, may be as dangerous to friend as to foe. Such mines must be, according to laws of war, designed to become inoperative within a few hours after being set adrift.

(B) TORPEDOES.

The modern submarine torpedo is about 20 inches in diameter and 20 feet in length; is self-propelled; is not steered by magnetic means; and keeps a fairly accurate course for several thousand yards at an average speed of more than 30 miles an hour. Its weight is approximately a ton and a quarter, and when traveling at normal speed possesses great momentum—in fact, in one case, when the high-explosive charge in the "warhead" failed properly to detonate, the body of the torpedo penetrated the steel hull of the ship attacked. Torpedoes are also provided with means to more or less effectively cut through screens, nets, or guards placed in their path.

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A torpedo is projected from a submarine or other vessel by means of a special form of tube or gun. A small charge of gunpowder or compressed air is employed to start the torpedo, after which—if of the usual self-propelling type—it is driven through the water by its own compressed air motor, the air being supplied from a strongly built reservoir within the body of the torpedo itself. The torpedo is kept upon its course by a gyroscope steering mechanism, which is immune to outside magnetic disturbances.

The detonation of the torpedo is accomplished through a mechanism placed within its warhead; and if the torpedo is either abruptly diverted from its course or is checked in its forward motion, the firing device, which is operated by arrested momentum rather than by any form of a projecting firing pin, instantly ignites the heavy charge of explosive contained within the warhead. The explosion, if it takes place within 20 feet of the vessel, will usually rupture the ship's plating, because of the terrific blow transmitted through the water from the point of the explosion to the ship's side. The depth at which a torpedo travels is usually between 12 and 15 feet below the surface.

CONFINING THE SUBMARINES.

The question as to why submarines are not destroyed before they reach the open sea is a most natural one, and the best answer which it is possible to give, according to the officers of our Navy and those of the foreign commissions who have visited this country, is as follows:

The submarine bases are very strongly protected by land batteries, aeroplane observers, and large areas of thickly mined waters extending to such distances that the largest naval gun can not get within range of the bases. In spite of these protections, there is now going on a continuous attempt on the part of the allied navies to entrap or otherwise defeat the submarines as they emerge from the protected areas. Nets are laid and as promptly removed by the enemy, whose trawlers are in turn attacked by our destroyers. The design of these nets and the detailed arrangement of their fastenings and attachments offer a broad field for invention, but it should be remembered that they must be capable of being used in waters in which there is a tidal current running from 2 to 5 miles per hour. Many suggestions for "bottling up" these bases have been offered, but, as will be realized, it is not desirable to publish information which would indicate even in the smallest degree this country's plans.

SHIPS AND SHIPBUILDING.

Many suggestions are made for ships of unusual form to provide for safety in case of a torpedo or mine exploding near or against the hull. Most of these plans are an elaboration of the usual water-tight bulkhead construction now required as structural design for all modern ships.

The multiplicity of water-tight compartments in any hull design tends to add to the vessel's safety.

The modern tank steamer used to carry fluid cargoes, such as petroleum products or molasses, is a good example of this design, which has been in general use for many years.

The explosion of a near-by submarine mine or torpedo frequently tears great rents in the ship's plating, in some cases opening a jagged hole 10 feet or more across, but the destructive effect on the hull of a ship caused by the explosion of a mine or torpedo may be greatly diminished by special hull construction.

General Instructions to Those Offering Suggestion to the Naval Consulting Board.

A very large proportion of the letters and plans that are received describe devices or schemes which are obviously impracticable or which show no novelty or improvement as compared with existing methods. After the elimination of these, the more meritorious inventions are submitted to the various standing committees of the board for examination. If an invention receives the approval of a standing committee, it is presented to the board with a favorable report and, if then again approved, it is forwarded to the Navy Department with the indorsement of the board.

The fact that inventions, plans, and devices must be forwarded to the various departments of the board for examination makes it essential that everything be presented in writing.

Communications should be addressed: Thomas Robins, Secretary Naval Consulting Board, 13 Park Row, New York, N. Y.

By means of the condensed information contained in bulletins, it is hoped that inventors and others who wish to present matters for examination will cooperate with the board by analyzing their own inventions. The board will thus be enabled by this help to spend a larger part of its time in the development of inventions, plans, or devices which are believed to be promising of assistance to the Government in prosecuting the war.

Presumably the Government intends to pay for inventions which it adopts, but as yet no specific provision has been made by law for this purpose.

Inventions and suggestions received by the Naval Consulting Board are examined in a preliminary way by the secretary, who is aided by the following committee of engineers:

Charles Messick—Lieutenant (j. g.), U. S. N. R. F., detailed to secretary's office, Naval Consulting Board; member American Institute of Electrical Engineers; patent attorney; developed and patented electrical hoisting and conveying machinery; developed and patented new methods in continuous casting of soft metal, including "Anti-slip metal tread"; developed and patented the combined clutch and adjustments device used on all modern motor cycles, etc.

G. Herbert Condict—Consulting engineer; member American Institute of Electrical Engineers; Franklin Institute; member executive committee, American Peat Society; past president New York Electrical Society. Among other activities, 1896–97, general manager and chief engineer Englewood-Chicago Electric Railway; 1897–1902, chief and consulting engineer Electric Vehicle Co., New York and Hartford; 1903–1906, vice president and general manager Electro-Dynamic Co. in New York; 1906–1909, general manager Box Electric Drill Co.; invented the series parallel resistance controller used on all trolley cars.

Howard W. Starr—B. A., Yale, 1895; M. E., Stevens Institute, 1900; vice president and manager Schenectady Power Co.; president East Creek Electric Light & Power Co., of St. Johnsville, N. Y.; vice president Mohawk Gas Co., Schenectady, N. Y.; vice president Theodore B. Starr (Inc.), New York City.

Carl K. MacFadden—Technical advisor of companies interested in petroleum; member Society Naval Architects and Marine Engineers; associate member American Society Naval Engineers; fuel-oil expert and consulting engineer for American and foreign companies.

Percy Adams Hutchison—Ph. D., Harvard; special correspondent with Atlantic Fleet in Mexican waters, 1914; naval training cruise for civilians, 1916.

Alfred Addison Thresher—Lieutenant (j. g.), U. S. N. R. F.; A. M., Denison University, 1891; formerly member American Society Mechanical Engineers, American Institute Electrical Engineers; associate member Society Naval Architects and Marine Engineers.

MEMBERS OF NAVAL CONSULTING BOARD OF THE UNITED STATES.

Addicks, Lawrence; Arnold, Bion J.; Baekeland, Dr. L. H.; Coffin, Howard E.; Craven, Alfred; Edison, Thomas A.; Emmet, William Le Roy; Hewitt, Dr. Peter Cooper; Hunt, Andrew Murray; Hutchison, Dr. M. R.; Lamme, B. G.; Maxim, Hudson; Miller, Spencer; Richards, Prof. Joseph W.; Riker, Andrew L.; Robins, Thomas; Saunders, W. L.; Sellers, Matthew Bacon; Sperry, Elmer A.; Sprague, Frank J.; Thayer, Benjamin B.; Webster, Dr. A. Gordon Whitney, Dr. W. R.; Woodward, Dr. Robert S.

Officers.—President, Tomas A. Edison; vice president, Dr. Peter Cooper Hewitt; chairman, W. L. Saunders; secretary, Thomas Robins.

THE ENEMY SUBMARINE.

[Bulletin No. 2, May 1, 1918. Compiled by the Naval Consulting Board and War Committee of Technical Societies from information already published and other recently released.]

FOREWORD.

This bulletin is prepared to supersede Bulletin No. 1, "The Submarine and Kindred Problems," issued on July 14, 1917, by the Naval Consulting Board; to indicate more fully the requirements for war inventions; to state the limitations outside of which creative effort may not be expected to produce results of value and to assist the student in avoiding the duplication of previous accomplishment. It is also intended to give wide publicity to certain general information already well known to the enemy, in order that the difficulties in overcoming the German submarine may be understood.

References from which detailed information in relation to submarine problems may be obtained, and a list of references with extracts in relation to submarine strategy and tactics, are included.

The Naval Consulting Board is acting officially as a national board of inventions and is conducting its work with the active cooperation of the War Committee of Technical Societies.

By means of the condensed information contained in bulletins, it is hoped that inventors and others who wish to present matters for examination will be enabled first to analyze their own inventions. By this help, the examiners can devote a large part of their time to the development of inventions, plans, or devices which give promise of assisting the Government in prosecuting the war.

EXPERIMENTS AND DEVELOPMENT.

The Army and Navy and the various civilian organizations cooperating with them are continually experimenting with and developing new ways and means to increase the effectiveness of the machinery of war. The Navy is giving special attention to the submarine and kindred problems, but for obvious reasons many of the details of this work can not be disclosed.

The amount of time and labor necessary to determine the value of a device, as compared with what is already in use, is infinitely greater than can be appreciated by the layman or even the average engineer. Few realize the stress, hurry, and lack of facilities in a battle. Any delay or difficulty in the operation of new devices in action is fatal. For these reasons many schemes and devices appearing practicable and effective in laboratory tests have to be abandoned when tried out in service. There is, therefore, a very wise reluctance on the part of the Government to undertake experiments with, or development of proposals that appear, on preliminary examination, to be of such a delicate or complex nature that they would probably, though perfected, lack the essentials of strength, ease of operation, and reliability.

No proposal which involves premises not based on the laws of nature, as understood and accepted by authorities, is entitled to be recommended for experiment and development, unless the inventor shows that he is thoroughly familiar with such laws and can demonstrate that there is a possibility of the accepted understanding being erroneous.

Experiments and development are unnecessary in the case of devices which, though apparently operable, do not promise greater efficiency than those already in use.

It may be stated that the inability of the Government to make use of most of the proposals submitted is due to the fact that the devices suggested are either already in use, less efficient than those now employed, or, for good reasons, are thought to be impracticable and open to one or more of the objections mentioned in the list below:

1. It has already been suggested and passed upon.
2. A similar device is already in use.
3. A desideratum, rather than an invention, is offered.
4. It is not considered practicable.
5. According to the authorities, such a device is not required.
6. Prevailing conditions render its use impossible.
7. The desired purpose is now more efficiently accomplished.
8. There is no known method of applying the suggestion.
9. Not practicable according to natural laws as known.
10. The facilities for construction are not available.
11. It would violate laws of war as interpreted by this country and its Allies.
12. It would be too dangerous to use.
13. A similar suggestion has been tried and abandoned.
14. The proposal is not fully understood.
15. Its use would interfere with handling a ship.
16. Not practicable under marine conditions.
17. Ineffective against submarines as now built.
18. Development in the art has progressed beyond that which is indicated by the proposal.

No proposal that is open to any of the foregoing objections will be recommended by the examiners.

Many proposals which depend for their operation upon effects which are contrary to natural laws as known have been submitted. Below is given an outline of some of the most popular misconceptions.

Electromagnets.—Although the laws governing the use of electromagnets are generally known and applied in a practical manner in a multitude of devices in common use, even the man of wide experience will be astonished at the limited range of their effect. For instance, the magnets used in our manufacturing plants for lifting heavy masses of iron or steel are designed to exercise maximum magnetic effect, and for operation require a very considerable amount of electrical energy; yet a magnet which can lift 20 tons, when placed in contact with an iron plate of that weight, will not lift 2 pounds of iron or steel if separated from it a distance of 2 feet. Therefore proposed devices which depend on the attractive power of magnets for their operation in deflecting or arresting torpedoes, mines, or submarines must be governed by the simple laws of magnetism. A torpedo weighing approximately 2,500 pounds and traveling at a speed of from 25 to 45 miles an hour will not be deflected to any considerable degree by any known application of magnetism; and it is not believed that an enemy torpedo, mine, or submarine will ever be found in a position to be interfered with effectively by any electromagnetic means, however powerful.

Detection by magnetic needle.—Tests made on an actual submarine have shown that the magnetic effects due to this mass of iron are quite limited in range. For instance, at 150 feet distance the magnetic effect due to a submarine is only about 1 per cent as much as the earth's magnetic effect.

Influence on compass.—The submarine is equipped with a gyroscopic compass that can not be affected by any magnetic influence from the outside.

Mine attached by magnets.—A magnet deriving its power from any battery that could be contained within a bomb would not be powerful enough to hold the bomb in contact with a boat running through the water; therefore the scheme is impracticable. The main point would be to locate the submarine. When the submarine is once located, very simple methods of disposing of it are at hand.

Electrical effects.—There is a general misconception regarding the electrification of water and the atmosphere. There is no known method of charging the sea with electricity; of shooting a bomb of electricity, or of charging the atmosphere with electrocuting currents. Suggestions along these lines should show that the writer has made research in the laws governing the application of electrical energy, and should contain sufficient proof of their feasibility to insure serious consideration.

On the other hand, applications of the transmission of electrical energy by means of alternating or pulsating currents—as used in wireless systems, for example—belong to a different class of electrical development. Inventive genius is rapidly improving apparatus of this type for the sending and receiving of signals and messages, and the possibility of valuable results in this field is unlimited.

The Submarine and Its Operation.

History.—The first recorded experiment in submarine operation was made by a Hollander, Dr. Cornelius Van Drebbel, who in 1624 constructed a one-man submarine operated by feathering oars, which made a successful underwater trip from Westminster to Greenwich on the Thames.

Dr. David Bushnell, an American inventor and graduate of Yale in the class of 1775, nearly sank the *Eagle* in New York Harbor during the Revolutionary War by the use of his little one-man-powered submarine, the *American Turtle.*

In England the American inventor Robert Fulton, in the presence of William Pitt, then chancellor, and a large number of spectators, blew up a brig by exploding a mine which he had placed under her bottom by the use of his submarine boat. Both of these inventors were discouraged and were refused the necessary assistance to enable them to develop further their ideas regarding submarines, although they had undoubtedly shown that there were great possibilities in the underwater type of vessel.

Various unsuccessful attempts were made to utilize submarines during the Civil War, but at that time their only means of offense was a torpedo on the end of a long spar, and the solitary recorded hit was disastrous to both the warship and the submarine. Just as the breech-loading rifle, a very ancient device, failed to come into its own until the invention of the metallic cartridge, the submarine had to await the invention of the automotive torpedo before it became a really efficient means of offense.

TYPES.

Modern types.—Modern submarines are divided into two general classes—the coast defense type of from 300 to 700 tons surface displacement, and the cruising type of from 800 to 2,500 tons displacement, having a radius of action of from 3,000 to 8,000 miles and capable of operating along the Atlantic coast of the United States from European bases.

Germany appears to be devoting her energy at present to the construction of a small group of a still larger type, reported to have a displacement of 2,800 tons, which also possesses superior gun equipment for surface operations, greater speed when cruising on the surface, very much more habitable quarters for the crew, and storage capacity for a larger number of torpedoes and other supplies.

"One-man" type.—Many hundreds of proposals have been received advocating one-man submarines and submarines of small size, to be manufactured in great numbers for the purpose of attacking and destroying the larger types of enemy submarines. This subject has been given exhaustive consideration and it has been conclusively proved that no small submarine can be provided with the necessary power, speed, equipment, and living quarters for the crew to enable it to operate successfully in the submarine zone. Even the smallest of modern submarines requires a number of devices for its successful operation: An internal-combustion engine, an electric motor—which also can be used as a generator to charge the storage batteries—water ballast and trimming tanks, pumps, air compressors, air-storage tanks, torpedo tubes, storage space for torpedoes, quarters for crew, and other machinery and auxiliaries.

Submarines carried by mother ships.—Proposals to have small submarines carried by mother battleships or merchantmen and put overboard have not received favorable consideration, because of the practical difficulties involved in launching and maintaining them. Although a special type of small submarine has been designed with the intention of having it carried upon the deck of a battleship and launched for operations in the immediate vicinity of the ship, no records of successful tests are available. The smallest type of modern coast defense submarines, which can hold the necessary apparatus to have a useful range of action, weighs about 300 tons; the handling of such weights from the deck of a vessel at sea can not be accomplished with any degree of safety.

Submarines for this purpose have been proposed many times and in some cases carefully designed. No really successful design, however, has been evolved.

CONSTRUCTION.

Hull construction.—Generally, the German U-boat—which is the designation for the enemy ocean-going submarines—is made with a double hull. The bottom space between the inner and outer hulls is used for water ballast; the top space is used for carrying fuel oil. Water ballast displaces the fuel oil as it is consumed by the internal-combustion engine.

The frequent statements that oil has been seen on the sea after a U-boat had been attacked may have merely indicated that the submarine's outer hull had been punctured. However, there is some oil slick on the surface when the exhaust mufflers are flooded.

According to recent statements, the conning tower in the latest type of German submarine is protected by a thin belt of armor plate, and the vital parts of the hull, which are exposed when operating on the surface, are also made heavier than the rest of the hull, to protect them at least from the smaller caliber guns.

Even if the periscope and conning tower are shot away, the submarine may still be able to keep afloat and operate.

Source of power.—The internal-combustion oil engine of the Diesel or semi-Diesel type is almost universally employed for surface operation in modern submarines, although much experimenting has been done with steam-driven craft, and many engineers believe that, for extremely high power, steam may yet be used effectively if some of the inherent disadvantages—excessive heat, etc.—can be overcome. The limit of practical size has almost been reached in the internal-combustion engines used in the latest type of submarine, and if more power is needed the engines themselves will have to be improved, or, perhaps, steam plants will be resorted to.

Owing to the fact that internal-combustion engines require a great deal of air for their operation, which is not available when a boat is submerged, submarines must be equipped with an electric motor run by storage batteries for underwater propulsion. It is, therefore, necessary, after the storage batteries are discharged by use, for the boat to come to the surface while its electric generating apparatus, driven by the internal-combustion engine, recharges the batteries.

Speed.—The speed of a submarine, like that of other vessels, depends upon the power of its engines or motors in overcoming the resistance of the hull to being driven through the water. For submerged operations the electric motor operates the propeller, the engine being uncoupled and the current for the motor supplied by storage batteries. This electrical equipment, if it be of high power, occupies much space and is extremely heavy, especially if an extended submerged range of action at high speed is desired. Therefore, the space for such equipment on the underwater craft has to be provided by increasing the size of the craft. If high surface speed is also required, larger and heavier engines must be installed, which necessitate an additional increase in the size and displacement of the vessel. Maximum surface and submerged speeds can not both be had in one type of submarine, and therefore a compromise which gives the most efficient general results has to be effected. The main engines in a modern submarine constitute approximately 8 per cent and the storage batteries 16 per cent of the total weight of the boat. If greater surface speed is required, the percentage of weight allotted to the engines is increased; or, if greater submerged speed, the weight of the batteries is increased and smaller engines installed. In general, submarines to be capable of the highest possible speed, both for surface and submerged operations, must necessarily be of the largest type, and many predictions of giant submarines are made.

German cruising submarines have a maximum speed of about 17 knots on the surface and 10 knots submerged.

Details of submarine construction are of less immediate importance than ways and means to protect surface vessels from submarine attack, but details of construction and of the many life-saving devices, such as detachable chambers or conning towers and other mechanisms which have been proposed, experimented with and discarded, may be found in the references mentioned on a subsequent page.

EQUIPMENT.

Listening devices.—The submarine when submerged so that its periscope does not project above the water is blind, but not deaf, for it is provided with sound detectors or microphones that will indicate the approach and direction of a ship, if its own machinery is at rest or moving slowly, with noise so slight as not to interfere with the listening.

The propagation of sound through water is more rapid and efficient than through air, because water does not have so great a cushioning effect upon sound waves. While we speak of sound waves, and can measure their amplitude in some cases, there is no bodily displacement of the medium through which they travel. In general the harder, denser, and more incompressible the medium, the more efficient the transmission of the sound waves.

The underwater listening devices which are so frequently availed of in submarines, and patrol boats and destroyers used to attack them, consist primarily of a large diaphragm or its equivalent in some other physical form. The diaphragm is submerged and the pressure of the water upon it tends to cause it to deflect inwardly to a slight extent. When the sound wave strikes the diaphragm the deflection is increased, and when the wave has expended itself it is followed by a reduction of pressure which allows the diaphragm to recover until the succeeding wave strikes it.

The human ear can detect sounds having periods of vibration as low as 16 per second and as high as 30,000 or 40,000 in extreme cases, so that there is a very wide range of pitch over which listening devices might be used.

The vibrations emitted from a submarine are usually of low frequency, and therefore the listening devices which are particularly designed for submarine detection have to be specially adapted to low frequency, at the expense in many cases of their capacity for receiving the high-frequency vibrations; whereas with submarine signaling devices designed to communicate from one vessel to another a frequency of several hundred vibrations per second is found to give better results.

In one typical form of listening device the diaphragm is provided with a telephone transmitter. The vibrations of the diaphragm vary the electrical resistance in the transmitter, which are either listened to by a telephone receiver directly, or amplified by means of relays, such, for instance, as the audion and other similar apparatus, which enable sounds to be heard which otherwise would be inaudible.

Ways and means to tune out extraneous noises, such as the falling of rain on the surface of the water, the noise of the pumps and other machinery on the boat carrying the listening device, and arrangements to determine the direction of the source of sound, have been given a great deal of study and been developed to a considerable degree of effectiveness. Sound waves tend to emanate from the source radially, which is availed of in the direction-indicating devices. However, the details of these devices are more or less confidential, and only the general principles can be made available to the public.

Periscopes.—The superior gunfire to be expected from a merchantman which has been properly equipped makes it prudent for the hostile submarine commander to obtain his observations, for accurate aiming of the torpedo, through a periscope.

A submarine is usually equipped with two or three periscopes, extending about 12 feet above the conning tower, the more recent periscopes being of the "housing" type, which permits them to be quickly raised and then drawn down after the observation, thus allowing the undersea boat to operate unseen much nearer the surface and not lose time in changing its depth of submergence.

It is rumored that the latest German U-boat has a short periscope, of from 4 to 6 inches in diameter, extending about 8 feet above the periscope "fair water," which incloses the stuffing box through which the periscope slides up and down. The periscope fair water usually extends 4 or 5 feet above the top of the conning tower. The short periscope is used when the boat is moving at considerable speed through the water. An additional periscope, which can be extended to a height of from 14 to 16 feet above the periscope fair water, is also provided. It is used only when the boat is stationary or nearly so. This taller periscope is used to reduce the chances of exposing the conning tower and hull of the submarine while patrolling in a rough sea, with the hull submerged. It is very small in diameter at the top, and is commonly called the "finger" periscope. Owing to the vibration prevailing at any speed above 4 knots, it can not be used when a submarine is moving rapidly. A third periscope, smaller in diameter, is usually provided as a spare, in case of accident to the two periscopes described above.

A periscope is usually designed to have about a 45° angle of horizontal field of vision, and the vertical field may be less. It is rotated by the observer, in order to scan the whole horizon.

When a submarine is cruising on the surface, the top of the periscope may extend to a height of 23 or 24 feet above the water, thus giving a range of vision of about 6 miles to the horizon, if the day is bright; while an observer standing upon the conning tower can see the horizon at a range of only about 4½ miles; however, the observer can usually see much more distinctly by his direct vision than through the periscope. The upper parts of ships can, of course, often be seen beyond the horizon.

Greatly increased optical efficiency in the periscope is not a theoretical possibility, although various sizes and designs of periscopes have been experimented with. Any increase of submerged diameter or length of periscope impedes the submerged speed of the submarine. The older type gave a great deal of trouble from defective mechanical construction; but the more modern devices are hermetically sealed by the manufacturer, and are reasonably free from condensation of moisture on the lenses and from vibration.

Experiments have been performed on the subject of decreasing the visibility of periscopes. It is very difficult to see a periscope, and the artistic use of paint, simulating foam and green water, is one of the best means of making a periscope invisible. A periscope so painted, projecting a few feet above the water from a motionless submarine, can be seen at a very short range only, and if it is thrust up in a quick observation and then withdrawn, the presence of the submarine is usually not disclosed.

The use of mirrors has been suggested and experimented with, but the conclusion has been reached that their use is not practicable. Any rolling of the submarine will change the angle of incidence and reflection and serve to reveal the position of the submarine.

Periscopes having their upper portions made of glass tubing, to reduce visibility, have also been proposed.

It is, however, the wake of the periscope on a moving submarine, rather than the periscope itself, that attracts the attention of an observer.

Torpedoes.—A submarine may be equipped with from one to four, or even more, torpedo tubes. These tubes are usually located in the bow, but some of the larger vessels also have tubes in the stern, and there are some with broadside tubes. These, however, are not German. The tubes in the submarine usually being built into the hull, it is necessary, in order to aim a torpedo, to maneuver the vessel so that the tube points at the target. Swiveled torpedo tubes are considered undesirable for submarine work.

A submarine carries as many torpedoes as possible, the number varying with the size and style of the boat. (See Torpedoes, p. —.)

Mines.—In addition to being equipped with torpedoes, some German submarines carry as many as 20 or more mines. (See Mines, p. —.)

Guns.—For surface operations, a submarine is usually provided, fore and aft, with guns of from 3 to 6 inch caliber. Sometimes these guns are secured rigidly to the deck, and sometimes housed within the hull and thrust up when they are to be used. A portable machine gun is also usually provided.

Wireless.—Telescopic or collapsible masts are provided, and wireless apparatus operated upon them, particularly at night, when the masts can not be seen by an enemy even if he is close at hand.

Net-cutting devices, etc.—Numerous devices and attachments have been provided to enable submarines to cut nets, put out divers, and to send a marking buoy to the surface in case of accident, and have proved more or less ineffective.

METHODS OF OFFENSE.

Bases.—Where a surface fleet of naval vessels has control of the seas, it is customary to have mother ships carry supplies and spare parts and to accompany a fleet of submarines; but unless the seas are so controlled it is necessary to supply the submarines from a shore base.

A base for submarines, to be of any value, must be easily and safely accessible, and equipped to provide a safe storage point for large supplies of liquid fuel, spare torpedoes, food, and other requisites for their proper maintenance. Its location, if in enemy territory, must, of course, be kept secret, as the discovery of a submarine base leads to the destruction or capture of the submarines dependent upon it. It is reported that one or more German secret bases, along coasts under control of the Allies have been discovered and destroyed.

Maneuvering.—In areas that are under intensive antisubmarine reconnoissance, both enemy and friendly submarines have to remain submerged a large portion of the time. If they remain on the surface during daylight, they are in constant danger from patrol vessels and aeroplanes. When operating in the open sea, submarines may remain on the surface most of the time, especially at night.

In maneuvering it requires at least 60 feet—preferably 100 feet—depth of water to remain concealed and safe from gunfire, ramming, or collision with surface craft. Submarines are frequently tested for safe operation at depths of as much as 200 feet, at which depth few effective obstructions, trawls, or nets can be used against them.

A modern submarine may, if it is in good order and the hull is not punctured, remain resting safely on the bottom for a day or more without inconvenience to the crew. Under favorable conditions, where the waters are less than 200 feet in depth, a submarine might lie at rest on the bottom and detect the approach of a vessel several miles away. In case the water is more than 200 feet in depth, a submarine must usually be kept in motion, to obtain steerageway, in order to hold its proper depth of submergence. This speed need not exceed 1 knot.

Method of attack.—Submarines, to operate most effectively, must approach within close range of the vessel which is intended to be torpedoed; but the installation of offensive weapons on the merchant marine has increased the necessity for the utmost care being exercised by the submarine commander to remain unseen. It is reported that, many times, a submarine has followed a slow-moving merchant vessel, at a safe distance, during the daylight and has remained undetected, but, as dusk approached and the visibility of the submarine decreased, the merchantman has been overhauled, when the submarine moved into a position to discharge one or more torpedoes at short range, with deadly effect. Reports from abroad indicate that in many cases submarines have remained along lanes of travel for periods extending into weeks, with the expectation of torpedoing certain vessels.

In its method of attack the submarine has many advantages over its adversary. The ship to be attacked presents a definite target of comparatively large size, and is easily seen by the submarine commander at a range where the submarine's periscope is usually quite invisible to those on the surface vessel.

Even though the submarine be cruising on the surface it is not easily seen, because it has a very low freeboard.

As the submarine approaches an enemy's surface vessel it submerges, the periscope being the only evidence of its presence. Periscopic sighting of the target is necessary, as it has been found impossible to see through an underwater window far enough for practical observation. In the event of accident to the periscope, a submarine must come to the surface for observation or else maneuver blindly. If the sea be rough, or the weather misty or foggy, the periscope may not be seen until its prey is destroyed by a torpedo, and in some cases not even then. The submarine commander thus has every opportunity to verify his adversary's identity, speed, and course, also to decide upon the most vulnerable point of attack, and to place his boat in the best position to discharge an effective shot.

Torpedoes may be discharged with equal effectiveness whether the submarine is on the surface or is submerged, but at the most effective range, say one-half mile or less, the superior gunfire and greater accuracy of the guns of armed merchantmen and war vessels (because of their higher and steadier gun platforms) make the defeat of the submarine, operating on the surface, probable—in fact, almost certain—if the torpedo attack is unsuccessful. A single effective shell might disable or sink the submarine, because of its relatively small positive buoyancy, while the surface vessel might have many shells strike it and still remain in a seaworthy condition.

Protection of Voyaging Ships From the Submarine.

This subject, which is occupying the public mind as is no other, divides itself into a number of problems, the most important being the following: Detecting the presence of submarines; nets, screens, guards, etc.; decreasing the visibility of vessels; speed of vessels; special ship construction; convoying.

DETECTING THE PRESENCE OF SUBMARINES.

Microphones.—Many merchantment and transports are equipped with microphones so that they may detect the presence of submarines, take the necessary and available precautions to defend themselves, or make escape. These instruments are of the same general type as those used by the submarines and have already been described under "Listening devices."

NETS, SCREENS, GUARDS, ETC.

Nets or screens to be attached to vessels.—Many designs of such devices are suggested, and most of them are intended to be attached to the hull of the vessel to be protected. Many other suggestions along these lines, differing only in some of their minor characteristics from the foregoing, have been received. Up to the present time not one of these proposals involving screens of any kind has received the approval of the Navy Department or of the merchant marine. The principal objections to these devices are that they are heavy, difficult to hold in position, unmanageable in a heavy sea, and that they interfere with the speed and with the ability of the vessel to maneuver. Many of the suggested devices would prevent the launching of lifeboats or rafts from the vessel. It is barely possible, however, that there may be developed some form of this general plan which will be found practicable. In no other field have so many suggestions or so many duplicate inventions been presented to the board.

Pontoons and guard boats.—Pontoons and boats, from which plates or screens are sometimes designed to be suspended, to intercept a torpedo, either self-propelled or towed on both sides of the vessel or convoy to be protected, have been proposed, but require so much power to propel that they are considered wholly impracticable.

Devices projected to intercept torpedoes.—Many forms of furled nets to be opened in front of an approaching torpedo have been proposed; nets contained in shells to be discharged from guns and to be released on striking the water; nets to be dropped over the side of a vessel when the torpedo's approach is noticed, etc. The operation of these devices, even if practicable as mechanisms, would require an appreciable time interval, and even if the torpedo's approach were detected, the few seconds intervening between its being observed and its striking the ship would probably be insufficient to permit of their use. Quick maneuvering of the ship, however, has frequently been effective in dodging a torpedo.

Torpedo deflectors.—No effective means has been found to destroy a torpedo in flight or to divert one from its course. Heavy charges have been exploded, experimentally, directly in front of and at the side of torpedoes, for the purpose of determining the possibilities of deflecting them from their course, but the regulating gyroscope of a torpedo immediately brings it back to its normal course, so that such methods may be considered as ineffective. Moreover, it should be understood that there is usually no knowledge that a torpedo is coming, until it actually hits the vessel.

The deflection of a torpedo by water or air jets operated at the sides of the vessel has been repeatedly suggested, but the power required to operate the pumps necessary to furnish the streams of water, and to give adequate protection against a rapidly approaching torpedo, would be much greater than that required to propel the ship. If the power were available, it might better be used to drive the vessel at increased speed, by means of the propeller.

Numerous experiments with devices employing magnets for arresting or deflecting torpedoes have been tried, with discouraging results. It has been found that magnetic influences are not felt at a practical distance. (See "Magnets, etc.," p. —.)

Mine sweepers.—Mine-sweeping boats and devices to precede a vessel entering or leaving port are sometimes used for the purpose of cutting the cables of submerged, anchored mines, sweeping them away or otherwise rendering them harmless.

DECREASING THE VISIBILITY OF VESSELS.

Smokeless combustion.—The point of lookout on a submarine being close to the water, the position of a vessel at a distance can be determined only by observing its smoke, which floats high in the air. Improved smokeless combustion is therefore desirable.

The visible particles in smoke can be scrubbed out with several well-known types of apparatus. The whole subject has been considered at length, and the conclusion reached that to handle the quantity of gases emitted from a vessel's stack would require such an amount of machinery and equipment as to make these systems inadvisable. The small submarine chasers are equipped with internal-combustion engines and emit no smoke. Torpedo boats and destroyers use oil fuel, and can suppress or emit smoke at will. Anthracite coal and other smokeless fuels have been tried on coal-burning vessels with good results.

A number of systems for the smokeless combustion of soft coal have been developed for operation in power plants and factories. Most of these systems involve the use of special types of grates and stokers which are not often found in the vessels at present in service; however, there seems to be no theoretically insurmountable obstacle in adapting the devices to marine work.

Smoke screens.—Under favorable conditions of wind and position many vessels have saved themselves from torpedo attack by the production of a smoke screen. This may be formed either by incomplete combustion of the oil used for fuel by most naval vessels, or it may be created by burning chemicals, such as phosphorus and coal tar or mixtures in which both of these and other materials are used.

After hiding itself from the submarine in a cloud of dense smoke, the vessel, if possessed of sufficient speed, may be able by a quick maneuver to change her position and escape before the submarine is able to discharge an effective torpedo.

Blinding enemy periscopes.—In some cases a quantity of heavy black petroleum or similar substance which will float on the surface of the water has been used to cloud the optical glass in the periscope's exposed end. However, in view of the ease with which most of these substances may be washed off and the vast area to be covered the use has been abandoned.

"*Camouflage*" *painting.*—Relative invisibility may also be afforded by methods of painting. The art of so-called "camouflage" is applied to the painting of ships, as well as to land warfare. Ships are sometimes painted to resemble the sea, and various devices have been proposed to conceal their character, size, and identity.

The visibility of ships may be greatly reduced by designing them with a low freeboard and eliminating masts, smokestacks, superstructure, etc., and this matter has been given a great deal of study.

Suggestions as to any other method of reducing visibility will be of interest.

SPEED OF VESSEL.

The undeniable evidence of submarine activity which has been accumulated during the past few months has demonstrated that the immunity of a vessel to submarine attack is dependent very largely on its speed and also its maneuvering ability. The percentage of vessels having speeds of 15 knots or more, and which have suffered from submarine attack, is very small; while the loss of slow vessels, having speeds less than that of a submerged submarine, is practically 100 per cent of those attacked.

The merchantman or other craft of high speed quickly passes beyond the range at which a high percentage of torpedo hits can be scored, but slower boats give the submarine ample opportunity to take careful aim and to score a hit with almost every shot.

A ship steaming at 20 knots will cover a distance of one-half mile in one and one-half minutes, but a ship at 10 knots takes three minutes, showing the greater chance to escape the high-speed ships have when the submarine has finally maneuvered into a position for the proper aiming of a torpedo; but as a submarine seldom has time to get into position to aim torpedoes accurately at a fast ship such a ship is almost immune to submarine attack, unless the U-boat happens to be lying submerged in its path.

Merchant vessels, in order to be fast and at the same time economical cargo carriers, must of necessity be of large size.

SPECIAL SHIP CONSTRUCTION.

The explosion of a near-by submarine mine or torpedo frequently tears great rents in the ship's plating, in some cases opening a jagged hole 10 feet or more across. The destructive effect at any given distance, at the point of explosion, depends to a large extent upon the framing and plating and may be greatly diminished by special hull construction.

Water-tight compartments and air cells.—Many suggestions are made for ships of unusual form to provide for safety in case of such explosions; most of these plans being an elaboration of the usual water-tight bulkhead construction, now required in structural design for all modern ships.

The multiplicity of water-tight compartments in any hull design tends to add to the vessel's safety. The modern tank steamer, used to carry fluid cargo, such as petroleum products or molasses, is a good example of this design, which has been in general ue for many years.

The honeycombing of hulls with air cells has been proposed in an infinite number of variations, and air tanks, such as are now used on life rafts, have also been suggested in various proposed arrangements for installation within the hulls of vessels.

The ordinary self-baling lifeboat, such as is used by the Coast Guard Service, probably represents the most highly developed form of nonsinkable ship that can be constructed. Its hull is filled with numerous water-tight cans or boxes, so that injury will merely admit water to the space occupied by the boxes, and only a little reduction of the buoyancy of the boat will occur, as each box is an individual float. It is very unusual for a lifeboat of this type to sink, even though the hull is badly wrecked.

The object of a passenger vessel is to carry passengers, of a freighter to carry freight, and of a war vessel to carry offensive armament. Air cells and water-tight compartments in their various forms decrease the convenience and carrying capacity of the different types of vessels, and the problem which has to be solved for each type is one of over-all efficiency. In other words, how much capacity is the designer justified in sacrificing in order to increase the safety from torpedo attack?

Cargo-carrying submarines.—Cargo-carrying submarines of many designs, either self-propelled or towed, have been suggested. They are expensive to build and operate, and are inefficient.

Life-saving devices.—Floating superstructure and many other special life-saving devices have been proposed, but an increase in the number of lifeboats, rafts, and regulation life preservers has usually been considered preferable, as most of the special devices are inconvenient and cumbersome.

CONVOYING.

It has long been the custom to provide convoys for merchant shipping and transports carrying soldiers. The advantage of the convoy is very great, where a number of unarmed ships can be protected against submarine attack by one or two destroyers, and convoys are being used wherever the need is most important. In many cases, however, the commanders of fast vessels prefer to trust to their speed rather than to allow themselves to be hampered by the necessarily slow speed of a convoyed fleet.

Offensive Against Submarines.

CONFINING TO BASES.

The question as to why submarines are not destroyed before they reach the open sea is a most natural one. The best answer which it is possible to give, according to the officers of our Navy and those of the foreign commissions who have visited this country, is as follows:

The submarine bases are very strongly protected by land batteries, aeroplane observers, and large areas of thickly mined waters, extending to such distances that the largest naval gun can not get within range of the bases. Nets, when laid, are promptly removed by the enemy, whose trawlers are in turn attacked by our destroyers. In spite of these protections, there is now going on a continuous attempt on the part of the allied navies to entrap or otherwise defeat the submarines as they emerge from the protected areas.

MEANS OF DISCOVERY.

Nets.—There are three general types of antisubmarine nets—the indicator net, the bomb net, the entangling net. The indicator net is solely for the purpose of detecting the presence of the submarine. These nets are generally made of light one-fourth-inch stranded wire and have about a 10-foot mesh, or they may be made of fiber rope. The bomb nets are also of light material, only sufficiently strong to carry the bombs. The entangling nets are made of much heavier material, but German submarines are now equipped with various devices for clearing themselves.

Antisubmarine nets are so placed that the upper edge is between 15 and 20 feet below the surface of the water. The waters in which nets are used are under such close surveillance that no submarine would operate on the surface there in the daytime. By keeping the top of the net under the surface its location is not disclosed to the enemy.

Nets and bombs.—The value of nets with attached bombs is problematical, owing to the great danger from the very rough handling which these nets invariably receive, especially when attempts are made to lay them in rough water. The bombs and the apparatus which is usually designed to explode them are heavy, bulky, and require occasional inspection for proper maintenance.

An almost imperceptible tidal current causes an anchored net to lop over to one side so much as to sink the top of the net to a surprising extent. The behavior of nets, either towed or anchored in a current, is very difficult to comprehend, until seen.

Trawling.—The dragging of trawls, or nets, by trawlers and destroyers, not only with the view of locating submerged submarines but also to sweep up mines, is frequently suggested. Under certain conditions this operation is practicable and effective, and has been constantly employed abroad since the beginning of the war.

Aircraft.—Aeroplanes, dirigible balloons, kites, and aircraft of all sorts are used for detecting the presence of submarines. They may be operated either from shore or from the larger ships, and are sometimes very effective; as, under favorable conditions, a submarine is discernible from aircraft flying at a proper height, even though the submarine be submerged to a considerable depth.

While aeroplanes have been thus used successfully in the English Channel, they are unable to operate far out at sea, where the submarines are now most active. The construction of mother ships for carrying and launching aeroplanes is necessarily a slow process under present conditions, when all shipyards are overloaded with other important work.

Optical detection.—Many devices which depend upon optical means of detection, such as special forms of telescopes and field glasses, to be mounted on ships or on scouting vessels, are suggested. Experienced and alert lookouts, however, have proved to be the most essential factor. Without such men, no optical device appears to be of value, and at night, or in bad weather, such devices are apt to be unreliable.

Wake of submarine or torpedo.—The fact that a moving torpedo leaves in its wake a stream of air bubbles caused by the exhaust air from its propelling engines offers under favorable conditions one means for discovering its approach. This evidence is, however, difficult to detect in a rough sea or at night, and, furthermore, the bubbles do not reach the surface of the water until after the torpedo has traveled onward a distance of from 50 to 200 feet toward its target. Only a very small percentage of torpedoes are seen.

Seeing under water.—Many proposals for boats with glass windows in the bottom and other means for observing submerged objects have been made. The waters in which submarine activity is most pronounced are so lacking in transparency that experiments have proved it impossible to see objects such as submarines at an average distance of more than 10 or 15 feet. Even in the clearest sea water, objects under the surface can not be seen if distant more than 100 or 150 feet.

Many special forms of searchlights and projectors, to enable an observer to see a greater distance through water, have been suggested and experimented with but so far none of these has proved successful.

It will be seen that each of the above methods, however useful, has its limitations; therefore, scientists and inventors should apply themselves not only to the task of improving these, but also of finding supplementary methods and devices.

PATROL FOR SUBMARINES.

In open waters, where storms and heavy seas are encountered, the patrol for submarines is generally carried on by large, fast boats of the destroyer type. In the more protected waters the patrol for submarines devolves upon light, fast surface craft, aircraft, and submarines.

SUBMARINES USED AGAINST SUBMARINES.

Submarines have very low visibility. They were primarily designed to operate against the large surface vessels, and it has been the general impression that submarines are not effective against submarines. This belief was also held by the general naval staffs of the various combatants at the beginning of the war; however, allied submarines have been successfully used in destroying enemy submarines.

In operating against hostile submarines, the hunting submarine may employ one of two methods—it may remain totally submerged and take observations by thrusting up the periscope every few minutes, or it may remain on the surface and only dive when the enemy submarine is sighted. In both cases the hunting submarine maneuvers very slowly, in order to avoid attracting the attention of the enemy, and to prevent detection by means of listening devices. The method of total submergence is used in restricted waters, such as channels and lanes through which the enemy submarine must pass. Torpedoes are used when submarines fight each other, and, if possible, the extremely effective ram. All submarines can ram without specially designed devices for so doing.

DESTRUCTION OF SUBMARINE.

A submarine is most vulnerable to attack from gunfire when it is on the surface, recharging the storage batteries; for the gases rising during this operation are stifling and must be vented into the air, and several minutes are required to close the hatches and submerge.

Quick-firing guns of sufficient caliber and depth charges are used by surface vessels, such as destroyers and chasers when they are unable to discharge an effective torpedo.

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Gunfire.—A rapid-fire gun is effective when the submarine is within close range of the gun; but when only the conning tower is exposed the target is so small that it is difficult to hit.

A submerged submarine can be reached with ordinary service shells only by high angle fire, because at low angles they ricochet on the surface of the water.

The Navy has one or more types of shell that penetrate the water satisfactorily, and any improvement would be along the line of straighter underwater trajectory and reduced underwater resistance. The screw-nosed shell has been suggested many times, but it would seem that inventors are laboring under a misapprehension, viz, that the shell will screw its way into the water, whereas a shell rotates only once in about 25 or 30 calibers, and the fraction of a revolution which it makes while entering the water is negligible.

Depth charges.—The powerful effect of any submarine explosion on all neighboring bodies provides a simple means of destroying or crippling an undersea boat. Once it has been even approximately located, the setting off of a heavy charge of high explosive, well submerged within about 50 feet of the submarine, will bring about this result.

Howitzers and mortars to throw depth charges at a submarine have been proposed, but the deck of a merchant vessel would have to be reinforced to support the recoil, if heavy charges were to be handled. Catapults have been proposed as a substitute for howitzers, but are believed to be theoretically and practically less efficient for this work.

Bombing hydro-aeroplanes.—The rapid development and improvement of the depth bomb, and the increased carrying capacity of the modern high-powered hydro-aeroplane, have made possible a new type of "bombing hydro-aeroplane," designed to carry a considerable number of bombs, each containing a heavy charge of high explosive.

Nests of torpedoes.—A great many nest arrangements of torpedoes have been suggested and considered, also torpedoes combined with nets, but the authorities do not believe that any of these combinations are as practicable as other means now at hand.

Towing mines.—The idea of having chasers towing mines has often been suggested and used to some extent. This is a good method when the whereabouts of the submarine are known.

Torpedoes influenced by sound.—Torpedoes to be controlled by sound have been frequently proposed, the torpedo to be tuned to automatically steer itself and strike the vessel destined to be destroyed. This design has been very carefully considered by torpedo experts and associated scientists.

To develop such a weapon would require years of experimentation and while a successful design might be attained, the relative increase in value would hardly compensate for the time and study necessary.

There are many methods for dealing with the submarine when its whereabouts are determined. The problem lies rather in locating the submarine.

TORPEDOES.

Size.—The modern submarine torpedo varies in size according to the service for which it is intended, and ranges from 14 inches in diameter and 15 feet in length to 21 inches in diameter and 21 feet in length, weighing from 1,000 to 2,600 pounds, the smaller type being used by the Germans to sink unprotected freight and passenger ships at short range.

Speed.—It is capable of a speed of more than 30 miles per hour, and when traveling at normal speed, possesses great momentum, about 65,000 foot-second pounds.

Method of discharge.—A torpedo is projected by means of a special form of tube or gun. The tube is usually built into the hull of the submarine, in which case it is aimed by maneuvering the boat. In the case of destroyers and battleships, the torpedo may be projected from submerged tubes or from deck tubes.

Generally speaking, torpedoes are projected from submerged tubes by compressed air and from deck tubes by a small charge of gunpowder. Submerged tubes on battleships, however, may be designed to use either powder or compressed air. When the torpedo is fired from a submerged tube, the compressed air or the gas from the powder follows the torpedo out of the tube with a rush, and causes an eruption on the surface of the sea, which is visible for a considerable distance. As a result of the warning given by this eruption, vessels have sometimes been able to escape the torpedoes by a quick maneuver.

Propulsion.—The modern torpedo is self-propelled, being driven through the water by its own compressed-air motor, the air being supplied from a strongly built reservoir within the body of the torpedo itself. Torpedoes directly operated by internal-combustion engines as motive power have been experimented with and discarded.

Range.—The range of a torpedo is approximately a mile, those designed for use on battleships and destroyers being longer ranged than those for use on submarines. The great difficulty in getting proper direction and sufficient motive power to give the required speed for a long duration of time renders the long-range torpedo impracticable. It is stated that the latest German torpedo has a range of about 2,000 yards, as the compressed-air storage reservoir has been reduced in size in order to increase the charge of high explosive in the warhead. The charge is said to be from 300 to 400 pounds.

Method of steering.—The torpedo keeps a fairly accurate course by means of a gyroscopic steering mechanism, which is immune to outside magnetic disturbance.

Course.—The depth at which a torpedo travels may be regulated to hit the most vital part of the vessel, and that is usually about 10 feet below the surface. In case of torpedo attack against an armored ship, the torpedo, to be dangerous, should strike beneath the armor belt, which usually extends about 10 feet below the water line.

Net-cutting devices.—Torpedoes are usually provided with means to cut, more or less effectively, through nets placed in their paths.

Detonation.—The detonation of the torpedo is accomplished through a mechanism placed within its warhead; and if the torpedo is checked in its forward motion, the firing mechanism instantly ignites the heavy charge of explosive contained within the warhead. It is not necessary to strike a firing pin on the end of a torpedo to detonate the charge.

Controlled by cable from ship.—Many suggestions have been submitted to the board for a torpedo to be electrically propelled from a ship by means of a flexible cable connecting it with the ship. This was the first type of torpedo built, but was discarded for the present dirigible type, as the weight of cable, difficulties in insulation, etc., render it of no practical value.

MINES.

Stationary mines.—Generally speaking, there are two types of mines—fixed and floating. The fixed or stationary submarine mine is fired by contact, electricity, timing device, or fuse. Such mines, which are extensively used by all navies, are rugged in design and may contain large charges of explosives. They are placed in position by submarines and other especially equipped mine-laying vessels. Such a mine is provided with an anchoring device and is deposited, if possible, in harbors and channels of the enemy or in the paths of ocean travel.

Floating mines.—Floating mines differ from fixed mines in that they are unanchored, and unless guard boats are at hand to warn friendly vessels of their proximity, may be as dangerous to friend as to foe. Such mines must be, according to laws of war, designed to become inoperative within a few hours after being set adrift.

The German floating mines are often cast adrift in pairs connected by a line about 100 feet long. If a ship runs between the two mines they are drawn alongside the ship and exploded.

Contact depth mines.—Many proposals have been received suggesting the use of a contact depth mine, which will rise to the surface if failing to contact. This type, however, is considered unnecessary and inadvisable. The essence of the depth charge is that it explodes in the vicinity of the submarine, in case it fails to strike the boat itself. The use of the contact depth mine presupposes the necessary accuracy to strike the target. The recovery feature is of no particular value, and would necessitate numerous safety precautions to insure absolute safety in picking up.

PROBLEMS OF AEROPLANE IMPROVEMENT.

[Bulletin No. 3, August 1, 1918. Issued by Naval Consulting Board of the United States and Engineering Council's War Committee of Technical Societies.]

INTRODUCTION.

Many of the greatest improvements in industry have been made by men who had but little practical experience or technical training along the line in question. But they brought to the task the requisites most needed—a free brain, a clear insight, and fresh enthusiasm.

Perhaps yours is the mind that will see the way to some great improvement in aircraft, one of the most potent weapons for winning the war. A billion dollars has been set aside for production. The finest shops and the best trained men in the country are working upon design and manufacture and we will soon have machines. But we want the best in the world. The men engaged in the details of the work are just now under a pressure which is not favorable for the exercise of creative powers. Technical men who are far enough from the work to see it in a different perspective, therefore, have a special opportunity for useful service.

In order to save you labor specialists have summarized in the inclosed bulletin the most pressing problems of aircraft improvement and have indicated probable lines of progress. Any help you can give will be welcomed. Inventions and ideas submitted in reply should be addressed to Thomas Robins, Secretary Naval Consulting Board. 15 Park Row, New York.

AEROPLANE MOTIVE POWER IMPROVEMENT.

The present situation with respect to the improvement of aeroplane motive power is that the Government is concentrating all its energies upon the quick production of the best design it has been able to select from present motor development. For manufacturing reasons it was obviously necessary to standard ize this design and just now the Government is not in a position to consider improved motors and systems of power. Such questions must be deferred if possible until after the pressing needs of the moment have been met.

At all times, however, advances which are great enough and which have been sufficiently proven, necessarily command a right of way. Power development is moving so swiftly and there is so much room for its advance that nothing is really fixed, and no nation is taking a chance of overlooking anything which is really worth while. Minor improvements, applicable with the present motor, can be considered at any time if they are of sufficient value.

POSSIBILITIES FOR RADICAL ADVANCES.

For war uses the cost of power is immaterial, the important object being:

(1) To secure steady, reliable operation.

(2) To obtain lighter weights than the 2 to 2.5 pounds per horsepower now attained (1.75 pounds without radiator, water, piping, propeller, etc.).

(3) To obtain more work per pound of fuel carried.

The room for improvement is evident from a view of the conditions under which the average aeroplane motor now operates (figures approximate):

	Per cent.
Energy of fuel delivered by engine shaft to propeller—thermal efficiency—for the indicated horsepower, 30 per cent: For the brake horsepower	25
Energy consumed by engine friction	5
Energy lost by cooling	30
Energy escaping in exhaust (including that of unburned fuel)	40
Total fuel contents	100
Mechanical efficiency of propeller	75
Net energy of fuel delivered by propeller and available for flight (0.75 × 0.25)	19

The field for radical improvements is an extremely broad one, covering all the possibilities of new power cycles and of gas turbine. No suggestions can be offered to those who wish to investigate these possibilities, but they can familiarize themselves with the subject through the bibliography attached.

Conservative Improvements in Airplane Motors.

By E. H. Sherbondy, United States Airplane Engineering Department, Bureau of Aircraft Production, War Department.

The following is a brief presentation of some of the problems encountered by aircraft motor and airplane designers, and also some suggestions relative to the improvement of apparatus and methods of function.

It is assumed that those interested in the development of apparatus required in this field of work are informed as to current progress. Engineers who are familiar with the development of power and general machinery, but who are without special knowledge of aircraft motors and their accessories are advised to read back issues of the American, English, and French periodicals devoted to aeronautics and automobile engineering. They should also look up the subject through the works upon internal-combustion engines given in the bibliography attached, which also includes a list of the periodicals which are of the most importance from a technical standpoint. American books upon aircraft motors are often of an elementary character unsuitable for the purpose in hand. Much valuable information will be found in the journals of technical societies mentioned in the bibliography.

The problems to be solved mainly refer to improvements in the motor-power apparatus, its specific weight; its thermal efficiency referred to brake horsepower and the reliability of its mechanical construction.

In order to do successful work in any line of invention it is desirable to have a definite idea of what is still to be accomplished and also more or less familiarity with the history of the particular art. Many helpful suggestions may be obtained from a study of experiments on various kinds of apparatus which have failed for reasons which may not be operative now through the existence of better materials and more knowledge or through the advance of the physical sciences and of methods of carrying out the intention of the invention. This point is illustrated by the history of automobile rear axle drives. For a long time straight bevel gears were used. The helical bevel gear was known many years ago, but no method had been devised by which it could be economically produced, so that it did not come into practical use until about 1912.

The present state of the art of designing aircraft motors may be briefly summarized as follows:

The engine types are practically standardized. There are two principal types—one having 6 or 8 vertical cylinders all in line; the other being the "V" type with either 8 or 12 cylinders. It should be added that the use of aluminum has increased enormously the possibilities of the radial types of motors in moderate powers, these being designed with either fixed or rotating cylinders and with either air or water cooling. To be useful for aircraft work an engine must not weigh more than 2.4 pounds per brake horsepower (1.7 pounds without radiator, water, piping, propeller, etc.). It must, moreover, be composed of parts which can be readily produced by American manufacturing methods. The thermal efficiency of current types of aircraft motors referred to brake horsepower ranges from 25 to 32 per cent, this being the proportion of the original heat contents of the fuel consumed which appears in shaft horsepower. While the efficiency of these engines is higher than that of any other type of prime mover, including commercial Diesel engines within the output range of aircraft engines, their economy is rather low at less than maximum horsepower, and every effort should be made to improve the economy at part load. The economy varies but little for considerable changes in altitude, so that in this matter the effect of altitude is not often of importance.

It should be borne in mind that improvements suggested for the present system of motor power should lend themselves to development to a practical stage within a short time, say, six months; that is, the apparatus should be experimentally proven and ready for production at the end of this period.

Elements of the power system susceptible to improvement are dealt with in the following:

CARBURETION.

For a given motor operating successively at two different altitudes under identical conditions, i. e., at the same speed and with the same carburetor adjustment (the same sectional areas for the passage of air, gasoline, and mixture), the amounts of air (by weight) drawn into the motor in the same time are proportional to the barometric pressures at the two altitudes. The volume of air drawn in remains the same. Since the density of the gasoline does not vary with the altitude, we may summarize the effect of changes in altitude upon the mixture quality as follows:

The richness of the carburetor mixture increases with the altitude. It varies inversely as the square root of the ratio of barometric pressures (assuming the motor speed and throttle position to remain constant). While this is approximately correct for ordinary elevations it is decidedly true at altitudes over 15,000 feet.

This leads us to a consideration of the subject of carburetor regulation for varying altitude. At present this regulation is effected by means of a device called an altimeter, whose function it is to control the flow of gasoline through the carburetor nozzle. This object may be accomplished either by reducing the size of the orifice through which the liquid flows, or by reducing the equivalent head above the orifice. The equivalent head can be reduced by making the pressure in the float chamber dependent upon the pressure above the carburetor throttle, or by adding more air to the carbureted mixture above the mixing chamber. These functions are carried out automatically in two types of carburetors so far developed. One of these is the product of the Zenith Carburetor Co., of Lyon, France. This comprises a barometric capsule which through a linkage operates a valve regulating the pressure in the float chamber. The other was developed by the Panhard-Levassor Co., of Paris, France, and in this there is a diaphragm acted upon by the atmospheric pressure and the pressure within the carburetor. The motion of this diaphragm controls an auxiliary air valve above the primary mixing chamber of the carburetor.

Like the density, the temperature of the air decreases at high altitudes, but the decrease follows no regular law. Figures showing the actual decrease in temperature during several flights up to 20,000 feet altitude were published in the Journal of the Society of Automotive Engineers for September, 1917. A change in temperature affects the quality of the mixture, since the viscosity of the fuel changes with the temperature, and the quantity flowing through a fixed size orifice varies accordingly. However, variation of the mixture quality as a result of temperature changes is very small compared with the variation due to changes in barometric pressure, and the complication of any thermostatic arrangement for correcting the rate of gasoline flow or of air admission might outweigh the practical advantages gained. The value of any such apparatus would depend entirely on the practicability of the form in which it appeared.

PRECOMPRESSION OF AIR SUPPLY FOR MOTOR.

This is one of the major problems on which aviation motor designers are at present engaged. Apparatus for this purpose must operate reliably and be light in weight; it must be designed with a view to very high mechanical and volumetric efficiency.

IGNITION.

This is a most promising field for experimental investigation. Owing to the fact that modern engines develop explosion pressures of from 400 to 600 pounds per square inch and a M. E. P. of 120 to 135 pounds, the problem of spark plugs is a difficult one.

The insulation must be capable of withstanding the enormous temperatures developed, and the plug must not leak. A slight leak past the insulation for a period of 30 seconds would cause complete failure of the plug. The spark points of the plugs must be maintained at a sufficiently high temperature to prevent an accumulation of carbon on them, and yet their temperature must not be high enough to cause preignition of the combustible charge. This means that the spark points must be maintained within a critical temperature zone. The chief trouble encountered with spark plugs up to date has been that at low engine power the temperature of the spark points is so low that the points rapidly become carbonized and the plug is short circuited. This carbonizing can be corrected by a better system of lubrication.

Heating and expansion of the insulated electrode tends to cause the insulator to fail by cracking or otherwise, and the fact that all good electrical insulators are poor conductors of heat makes it difficult to keep the temperature of the insulator down and protect it from injury by overheating. The best minds in this field of activity are now working toward a solution of this pressing problem. References to this subject may be looked up in the Journal of the Society of Automotive Engineers under the headings of "Ignition" and "Spark plugs." The generating and distributing apparatus required and the ignition wiring have been developed to a high degree of reliability, and unless some entirely new scheme of ignition can be devised which overcomes the difficulties of the present system we feel that the jump-spark ignition system will maintain its present unique position, having no competitors. Nevertheless, it is to be observed that in reliability the present ignition systems still leave a good deal to be desired. Moreover, the weights are too high, and a larger output of energy per cylinder would simplify the plug problem.

ENGINE PARTS.

Engine parts of all kinds are generally very reliable, and an analysis of the failures of parts in French aircraft engines during 1915 and 1916 revealed no single part whose failures represented more than 2 per cent of the total number. Thirty per cent of the interruptions of power were due to hits by projectiles which affected some portion of the power system.

SELF-STARTERS.

Starting systems may be of three kinds—air, electric, and powder shell. Air starters and electric starters are usually applied to the motors of seaplanes, as seaplanes are not required to operate at very great elevations or at very great speeds; so the additional weight of the starting apparatus is not a serious objection, but in reconnoissance and fighting planes the weight must be kept at a minimum in order that speeds of 140 to 180 miles per hour and very great altitudes may be attained. In a few cases air starters have been fitted to aircraft engines mounted in fighting planes. The system makes use of an air bottle for supplying the required amount of air under the proper pressure. This air is either led through a distributor to the motor cylinders or is used to operate a multiple-cylinder air engine connected with the motor crank shaft by means of an overrunning clutch.

At the time of writing all starting systems have been discarded for battle planes. However, as we in America have developed electric starting systems of rather light weight to a high degree of reliability these may be fitted to motors mounted in bombing planes, which are usually equipped with multiple motors and do not necessarily have to be of very high speed. The Sheffield Car Co., of Michigan, has built gasoline railway cars in which the gasoline motor is started by means of a charge of black powder detonated by a special mechanism in the cylinder head, and it is possible that this idea may be developed until practical results are obtained, although the problem is very difficult in motors with a large number of cylinders.

EXHAUST MUFFLERS.

Exhaust mufflers would be desirable provided their weight was not excessive and they were effective in muffling and proof against injury from excessive heating. Since aircraft motors of to-day are 200 to 600 shaft horsepower and heat is constantly passing out with the exhaust gases at a rate equal to twice the useful power, it is at once apparent that the construction of a suitable muffler for aircraft engines is not a simple problem. An automobile muffler is called upon to radiate about one-tenth the amount of heat which would pass through the aviation muffler. Experiments in connection with this problem have been carried out at Cornell University, and the results obtained were published in the trade papers. In working out the problem it will be necessary to guard against any interference with the cooling of exhaust valves by radiation and conduction.

COOLING RADIATORS.

Cooling radiators are one of the most vulnerable points of the modern fighting machine, the system of cooling used being substantially the same as that on automobiles. However, the cooling capacity of a given sized radiator is greatly increased on an airplane by reason of the high speed at which air passes through the tubes. The form of radiator and its location are subjects which are usually left to the plane designer. A radiator may absorb 20 per cent of the engine power if it is not properly placed or designed for free air flow. A remarkable paper covering the whole subject of engine cooling and radiator design was published in 1916 by F. W. Lanchester in the proceedings of the Institution of Automobile Engineers, and should be consulted by anyone interested in this subject.

FUEL SYSTEM.

Fuel storage and supply systems are by no means satisfactory, and although a great deal of thought and ingenuity have been spent upon the design of these parts, this still remains a fruitful field for suggestion and invention. The arrangement of the fuel tanks and lines and the method of fitting the fuel tanks to the motors are probably the least settled features of aircraft construction. A suggestion in this connection is to make the tanks and fuel lines of same high resistance steel, so as to make them bullet proof. The objection to this is the great weight entailed, but this might be minimized by the development of special alloys possessing little weight and great strength.

FUEL.

The present type of aircraft engine operates successfully only on gasoline having a boiling point not exceeding 250° F. Hydrocarbon fuels of higher boiling points are apt to crack or become dissociated under the combined action of the high temperature and pressure, with the result that compounds are formed which produce a smoky exhaust. If we could find a fuel which carried the oxygen required for its combustion, the power of aviation motors would be affected neither by the altitude nor the temperature of the atmosphere.

PROPELLERS.

The subject of propeller design and construction is an extremely difficult one, since propellers must operate at enormous speeds in an atmosphere of varying temperature and density, and are subject to very complex stresses. Very important technical papers on the design of propellers have appeared in English and French aeronautic magazines, and in particular the eexperiments of G. Eiffel and A. Guret, which were published in France, are of the first importance. Propeller design and construction have been discussed also in engineering papers in our own journals of aviation.

MACHINE-GUN SYNCHRONIZERS.

Machine-gun synchronizers originated in France in 1915. Their object is to permit of firing a machine gun through the arc between the propeller blades. An important paper dealing with this apparatus was published in France in 1916, under the title "Les Avions Allemands." Librairie Aeronautique, 40 Rue de Seine, 40 Paris. (Copies of this pamphlet may be had from the book dealer Brentano, Fifth Avenue, New York City.)

INSTRUMENTS.

Many new instruments have been devised for aircraft. These include barographs, which indicate and record altitude; drift meters, which indicate side slip of the plane through the air; inclinometers, which indicate the angle of the plane; tachometers, which indicate the engine speed; oil, gasoline, and water gauges, which indicate the pressure and temperature of these fluids;

and speed indicators, which indicate the speed of the plane relative to the air through which it is traveling. All of these devices are capable of being further improved. Two instruments which it would be very desirable to have would be one giving the speed of the plane relative to the ground and one showing the altitude of the plane above the ground. Pilots flying at night with a barograph know only their altitude above sea level, and as they may not know the character of the ground over which they are flying, when they fly at low elevations (1,000 to 2,000 feet above sea level) they are not at all certain that they are at a safe altitude.

New cycles of operation for heat motors and the improvement of old ones are possible and desirable. The most available cycle, which is susceptible of immediate practical development, is the two-stroke cycle, and engines of this type have been built in great numbers, though the type has attained an important position only in the Diesel marine and stationary engine field. Adhering to the principles that have been found indispensable to the successful development of marine Diesel two-stroke engines, some useful results might be obtained. It is quite possible that an aircraft engine may be developed with a weight per horsepower not more than one-half that of our present engines and with a thermal efficiency (referred to brake horsepower), especially at less than maximum power, better than has been secured with the four-stroke cycle engine up to date. The subject of charging—that is, supplying the fuel and mixing it with the required amount of air—affords great possibilities for development.

Problems in Aeronautics.

By Dr. W. F. Durand, Scientific Attaché, American Embassy, France; Lately Chairman the National Advisory Committee for Aeronautics.

MATERIALS FOR AIRPLANE CONSTRUCTION.

For wing surface or covering, linen or cotton fabric is now in common or practically universal use.

Sheet metal or metal fabric has received some attention. The chief advantage would be noninflammability and perhaps greater durability.

No wing covering can be considered which is markedly heavier than present forms for the same strength. Present coverings weigh from 4 to 4.5 ounces per square yard and have a tensile strength per inch of width of 70 to 80 pounds.

Any proposed substitute form must also give a smooth and continuous surface comparable with present forms.

For the wing skeleton or frame, spruce and wood veneer are commonly employed. Broadly speaking, the frame is of wood construction of one design or another.

Steel or aluminum alloys are attracting attention and seem to offer possibilities.

Any form of construction in metal must meet sensibly the present relation between strength and weight. This means that the wing must be capable of sustaining up to the point of rupture a distributed load of not far from 100 pounds per square foot.

No one should undertake the development of such construction without expert advice in applied mechanics, experience in steel construction, and with large shop and fabricating facilities available.

For fuselage construction the present materials are commonly spruce, ash, and wood veneer. Heavier woods, such as ash, can here be used to some extent.

Steel or metal construction seems here also to offer hopeful possibilities, but under general limitations of equivalence regarding weight and strength compared with wood.

TIRES AND FASTENINGS.

The use of steel-wire cable for ties is standard and practically universal. It seems hard to imagine material superior to the best modern alloy steel wire, but there seems no reason for assuming that such material represents the last word in the wire maker's art, and there is therefore room for improvement even here, both in the material employed, in the mode of laying up wires to form a complex tie member, and in the form of section of such member.

Joint fastenings are commonly made of sheet steel or sheet bronze. There is room for improvement expressed in terms of ease of manufacture, economical distribution of material, facility for attachment of wire or cable ties, and general adaption to purpose.

SUPERCHARGING ENGINE.

The cylinder of the aeronautic engine takes in per cycle a cylinder full of air at substantially the atmospheric pressure about the carburetor. As the airplane ascends, the density of the air diminishes and there is, therefore, taken in per cycle a decreasing weight of air and hence a decreasing weight of oxygen. This reduces correspondingly the amount of fuel which can be burned per cycle and hence the power developed.

It results that, as the airplane ascends to high altitudes meeting air of decreasing density, the power falls off accordingly, and very nearly in proportion to the density.

To meet this difficulty means are desired for supplying to the engine or to the carburetor air at a nearly constant air pressure. This implies some form of air compressor taking in air at reduced pressure and density and delivering to the engine air at normal or nearly normal atmospheric pressure and density.

This problem has already been solved or approximately solved so far as merely compressing the air is concerned. It is primarily a problem of finding the best way of meeting the various limiting requirements regarding space, weight, reliability, etc.

TWO-CYCLE ENGINE.

If an engine operating on the two-cycle program can be developed, with fuel economy and general reliability equal to that of the four-cycle engine, the relation of weight to power should admit of substantial reduction. This is a favorite field for inventors, and a large number of designs and suggestions have been submitted. The field is still open.

PITCH-ADJUSTING PROPELLER.

Closely connected with the maintenance of the power of the engine at increasing altitudes is the problem of efficiently utilizing such power through the propeller. To this end some variation of pitch is desirable in order to maintain a proper relation between the torque of the engine and the resistance of the blade working in air of varying densities. Such variation of pitch is normally attended with loss in efficiency. Such loss should be reduced to the minimum. The problem here is one partly of propeller design with reference to aerodynamic qualities and partly one of structural design with reference to an operating and reliable form which will admit of adjustment of pitch to meet changing conditions of operation. Such change may be placed under hand control or under automatic or semiautomatic control between the limits imposed by the construction.

SPARK PLUGS.

The general style of modern spark plug is the result of an evolution determined largely by the conditions of operation of the automobile engine. With the higher compressions which are coming into vogue for the aeronoutic engine, increasing difficulties are met with in the spark plug, particularly as regards the breaking down of its electrical insulating qualities.

A spark plug, apparently good in appearance, may last for many hours' hard service or it may give out after a few hours' running. The problem of ignition, especially for the aeronautic engine, is one still awaiting satisfactory treatment.

PARACHUTES.

These considered as a safety device are not desired as a factor in the equipment of military airplanes. No entirely satisfactory disengaging device has yet been developed. Such devices may presumably play some part in civil aeronautics and under peace conditions, but under existing military conditions they are not considered a necessary or desirable encumbrance.

STABILIZING DEVICES.

The general subject of stabilizing devices is a favorite field for inventors. Broadly speaking, there is small likelihood for the favorable consideration of such devices under present war conditions. Aeronautic engineers already know perfectly well how to give to an airplane any desired degree of stability in any one of the various senses in which the word is used. The problem is to combine judiciously the various modes of stability together with the qualities which are needful for military purposes. Without thorough training as an expert the average student of the subject is not likely to produce anything distinctly new or available in this particular field of aeronautic design.

SELF-STARTERS.

With increase in size and power of engines, the need of mechanical starters is becoming more and more clearly defined. The self-starter is a now recognized feature of seaplane equipment, and is attracting increasing interest as a feature for land machines. Both electric and compressed air forms have been developed to a certain degree of efficiency. There is room for improvement as regards (1) size, (2) weight, (3) reliability.

AIRPLANE INSTRUMENTS.

Bomb-sighting devices form a favorite field for the inventor. No one should enter this field without familiarity with the forms which the French and English have developed, and without a clear understanding of the conditions to be met. Target practice with bombs dropped from considerable altitudes is decidedly poor and apparently is likely to remain so, regardless of the excellence of the sighting device as such. There is doubtless room for improvement in present forms, but the problem is not one which should be undertaken without a careful consideration of all factors entering into it.

Speed-indicating devices for showing speed through the air are in a fairly satisfactory condition. For the most part these instruments represent special forms of the Pitot tube and of the Venturi tube. These instruments have been made the subject of a vast amount of scientific investigation and so far as existing forms are concerned, it does not seem likely that much improvement is to be expected.

Speed-indicating devices for showing speed over the ground. There is a distinct field of usefulness for a device suited to show continuously or at very brief intervals the speed of an airplane over the ground.

Altitude indicating devices consist of some specialized form of aneroid barometer and are apparently in as satisfactory a condition as the delicate nature of these instruments permits us to expect.

Drift meters for showing the angle between the fore and aft line of the airplane and the direction of actual motion, have been developed, but there is room for improvement.

True vertical indicating devices have been proposed in great numbers, but for the most part of the ordinary pendulum or spirit-level type. All such are worthless. On the other hand, the methods of combining gyroscopic elements in such manner as to secure the desired result within an acceptable margin of error are perfectly well understood. It is not worth while attempting to develop such instruments by the use of the pendulum or spirit level principle.

Aircraft Problems.

By W. B. Stout, Technical Advisor Aircraft Board.

AERODYNAMICS.

The development of wing curves of greater lift-drift ratio; that is, a greater lift with less resistance to forward travel.

The development of wing curves of a high-speed type which will have a small center of pressure movement through large angles of incidence. In making experiments to this end it will be necessary to use wind tunnels which give wind speeds exceeding 100 miles per hour.

PERFORMANCE.

A study should be made of new mechanical arrangements of known aerodynamic features, in order to increase the range of flying speed, to minimize landing danger, and to minimize fuel consumption through the elimination of all parasite resistance possible.

A study should be made of new plane arrangements designed for greater visibility, for greater gun range, for quicker maneuvering, and for greater stability.

The further possibilities of lightening the construction of airplanes and of making them more reliable should also be investigated. Anything which would tend to change the airplane from its present kite-type construction to a more stable and long-life design would be in line with this thought.

PRODUCTION.

The greatest problem connected with the airplane as related to America is the development of production constructions which will permit airplanes to be turned out by methods already in use in this country for quantity production.

This problem would include intensive research upon the substitution of metal for wood wherever this is possible; also experiments with new steels and alloys and their heat treatment, which would enable ribs, spars, struts, ailerons, etc., to be made in thousands by machinery instead of in hundreds by handwork. Our eventual success in the air will depend upon the ingenuity with which we can produce, first, quantity of airplanes, and, second, quality. The Germans lead to-day in the quantity production designs.

In this connection a new covering for wings would be valuable which would be fireproof, waterproof, tough, and resilient, and would take the place of the short-lived fabric now used. Fabric should weigh within 4 ounces per square yard and should have a tensile strength of 75 pounds with 1-inch width.

PROPELLERS.

The airplane propeller presents a large field for research. Wooden propellers are far from satisfactory, though as yet no substitute has been found. Time should be spent in developing propellers which will permit motors to operate at the best speed (around 2,000 revolutions per minute) without the necessity of gearing down from motor to propeller.

INSTRUMENTS.

For airplane navigation better instruments could be developed. The compass is far from satisfactory, with the gyroscope compass not yet developed in light enough form. It is very possible that the future steering of airplanes will be along wireless rather than magnetic lines with definite control between cities.

ENGINE PROBLEMS.

Our engine program includes for war service, and very wisely, practically one type of engine. England alone is said to have some 36 types, making the service proposition almost impossible.

Germany has only three or four makes of engines, developing them to a greater degree of perfection every few weeks. Our own Liberty engine is 50 per cent better than it was six months ago and will be better still six months from now. If our dvelopment forces were being expended upon a hundred different engines instead of one, as would be the case if all or even our best engineers were allowed to work on aircraft engines promiscuously, no one of the engines would be fully developed in anywhere near the time that is possible by the present method.

Practically no difficulty is being experienced with the engines themselves, and now there are but few relating to the airplane chassis and fuselage. The main problems are in the connection of the engine with the airplane, and in the accessories which are necessary for the proper control of engine and plane. This includes the arrangement of pipe, wire, radiators, water connections, etc. New ideas for simplifying these parts are worthy of study.

New arrangements of tanks to make the plane more bullet proof and to decrease fire danger should be studied.

The recent developments in airplane motors all show that new things are about to be accomplished in the direction of high-speed short-distance work, and this field of research should not be neglected.

TYPES OF PLANES.

After the development of flying instruments reached a certain stage, night flying became popular. There is a demand already existent for planes of exceedingly large type capable of carrying tons of bombs and flying at night. This requires them to be stable. These machines should have from two engines up, and should be fitted with illuminating apparatus. Electric lights are not suitable, but magnesium flares have been developed for this purpose. Night flying also involves new problems in protective measures relating to anti-aircraft guns, searchlights, and combat tactics.

Considerable speed can be added to all types of planes.

LETTER ADDRESSED TO THOMAS A. EDISON BY THE SECRETARY OF THE NAVY.

DEAR MR. EDISON: JULY 7, 1915.

I have been intending for some time to write you expressing my admiration at the splendid and partiotic attitude you have taken, as reported in the public press, in refusing to devote your great inventive genius to warlike subjects except at the call of your own country. Such an attitude, in these all too commercial times, is one that should be an inspiration to our young men and a lesson in the preeminent right of one's own country to the best that its citizens have that will be of tremendous benefit to us all. I have deferred writing you, however, because, at the same time, I wanted to take up with you another matter to which I have given a great deal of thought—a matter in which I think your ideas and mine coincide, if an interview with you recently published in the New York Times was correct. There is a very great service that you can render the Navy and the country at large and which I am encouraged to believe, from a paragraph in Mr. Marshall's interview, you will consent to undertake, as it seems to be in line with your own thoughts.

One of the imperative needs of the Navy, in my judgment, is machinery and facilities for utilizing the natural inventive genius of Americans to meet the new conditions of warfare as shown abroad, and it is my intention, if a practical way can be worked out, as I think it can be, to establish, at the earliest moment, a department of invention and development, to which all ideas and suggestions, either from the service or from civilian inventors, can be referred for determination as to whether they contain practical suggestions for us to take up and perfect. We, of course, receive many suggestions, but our only way of handling them at present is to leave them to various bureaus already overcrowded with routine work, and it is not always possible to give the necessary attention to propositions that are not so definitely worked out as to make them immediately available for the service. Ideas which contain the germ of improvement can not always be given the attention they deserve, as there is at present no adequately equipped department to which to send them for the careful study required. In addition our naval officers, particularly those at sea, are in a position to note where improvements are needed and to devise ways in which those improvements can be made. They have, however, neither the time nor the special training, nor, in many cases, the natural inventive turn of mind needed to put these ideas into definite shape. Were there a place where they could be sent to be worked out and perfected, I am sure we would get many noteworthy improvements from this course alone. We have, of course, in the Navy Department energetic and wideawake bureaus, headed by experts in their particular lines of work, who devote all the time they possibly can to a study of this problem. They have made important contributions to the improvements in the implements of naval warfare and are doing all that is possible with their other large duties. There are, unfortunately, no officers now detailed who can take time from the mass of work which they are called upon to do in order to devote it fully to studying new suggestions and inventions. The department is also unprovided with the best facilities for work of pure experimentation and investigation with the exception of our testing station at Annapolis, which is, as yet, a small affair. Most of all, as I have said, there is no particular place or particular body of men, relieved of other work, charged solely with the duty of either devising new things themselves or perfecting the crude ideas that are submitted to the department by our naturally inventive people.

I have in mind a general plan of organizing such a department which is still very hazy as to details but which, in a general way, meets, so far as the Navy is concerned, with your ideas of such a department for the Government in general. I want to use such facilities for experimental and investigation work as we have, under the direction of men particularly selected for ability shown in this direction, to whom would be referred all suggestions of new devices sent in to the department, and who would work out such ideas to a practical point. Such a department will, of course, have to be eventually supported by Congress, with sufficient appropriations made for its proper development, although I feel that we can make a start with the means at hand. To get this support Congress must be made to feel that the idea is supported by the people, and I feel that our chances of getting the public interested and back of this project will be enormously increased if we can have, at the start, some man whose inventive genius is recognized by the whole world to assist us in consultation from time to time on matters of sufficient importance to bring to his attention. You are recognized by all of us as the one man above all others who can turn dreams into realities and who has at his command, in addition to his own wonderful mind, the finest facilities in the world for such work.

What I want to ask is if you would be willing, as a service to your country, to act as an adviser to this board, to take such things as seem to you to be of value, but which we are not at present equipped to investigate, and to use your own magnificent facilities in such investigation if you feel it worth while. For our part we will endeavor not to bother you with trivial matters, as we will probably have sufficient facilities to handle such small matters as they come up. This is a great deal to ask, and I unfortunately have nothing but the thanks of the Navy, and I think of the country at large, together with the feeling of service to your country that you will have, to offer you by way of recompense; yet so clearly have you shown your patriotism and your unselfish loyalty to your country's interests that I feel justified in making this request.

We are confronted with a new and terrible engine of warfare in the submarine, to consider only one of the big things which I have in mind; and I feel sure that with the practical knowledge of the officers of the Navy, with a department composed of the keenest and most inventive minds that we can gather together, and with your own wonderful brain to aid us, the United States will be able as in the past to meet this new danger with new devices that will assure peace to our country by their effectiveness.

If you feel that you would be willing to do this, I would like, a little later when my plans are somewhat more matured, to consult with you as to the details of the organization proposed so that I can make it as effective as possible for the purpose intended.

With you it might be well to associate a few men prominent in special lines of inventive research, and I would like also to consult with you as to who these men should be. It is, of course, your aid that I rely upon most, and if you are not able for any reason to do this I will frankly hesitate to undertake the matter at all. Should you feel like accepting the task, however, I know the relief which the country would feel in these trying times at the announcement that you are aiding us in this all important matter.

If you could let me know, as early as you may, how you feel about this I would appreciate it, as everything waits upon your answer, and I think we can not be too expeditious if we are going to take this matter up at all.

Hon. THOMAS A. EDISON,

East Orange, N. J.

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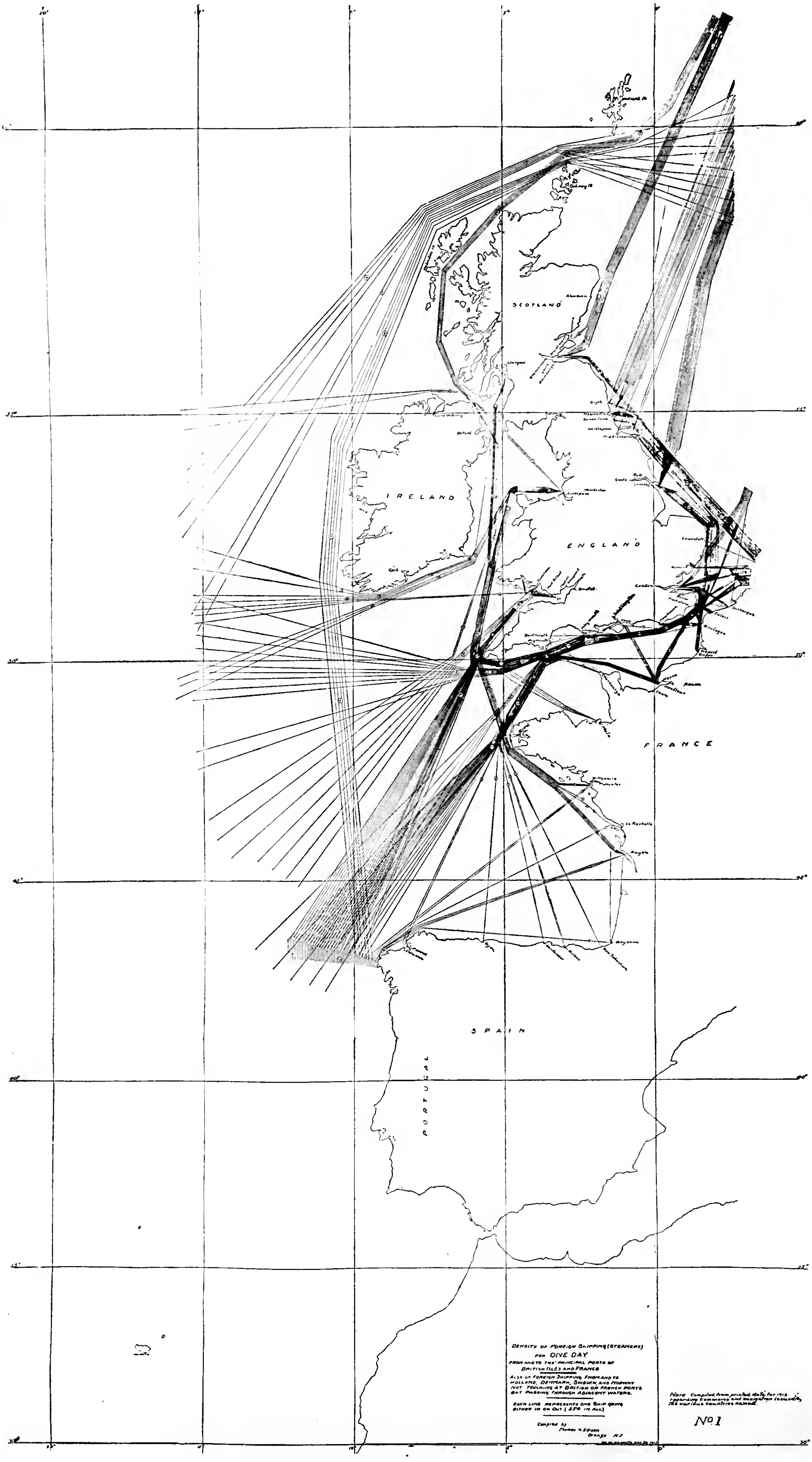
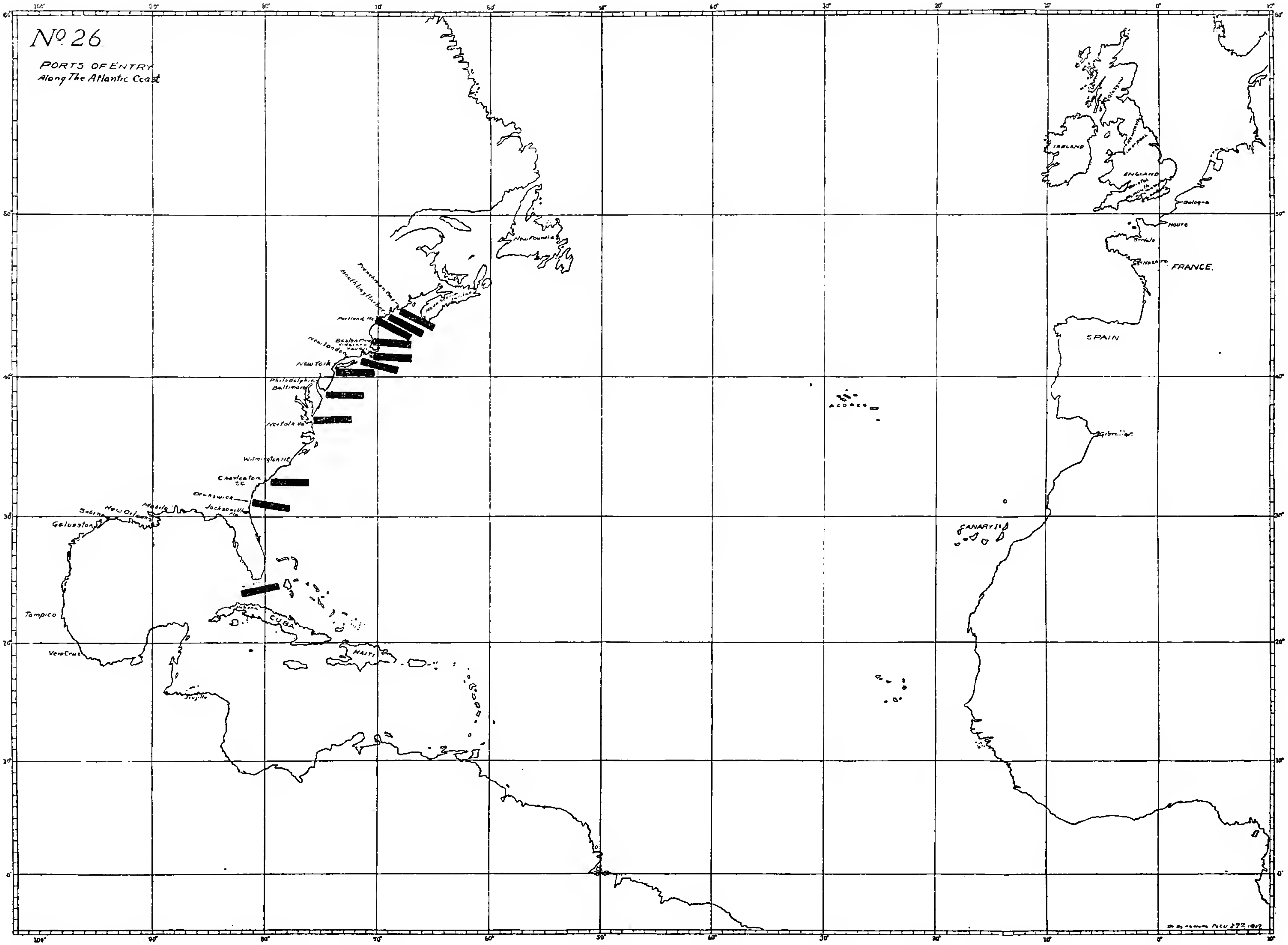
168837°—20. No. 1. (See p. 167.)





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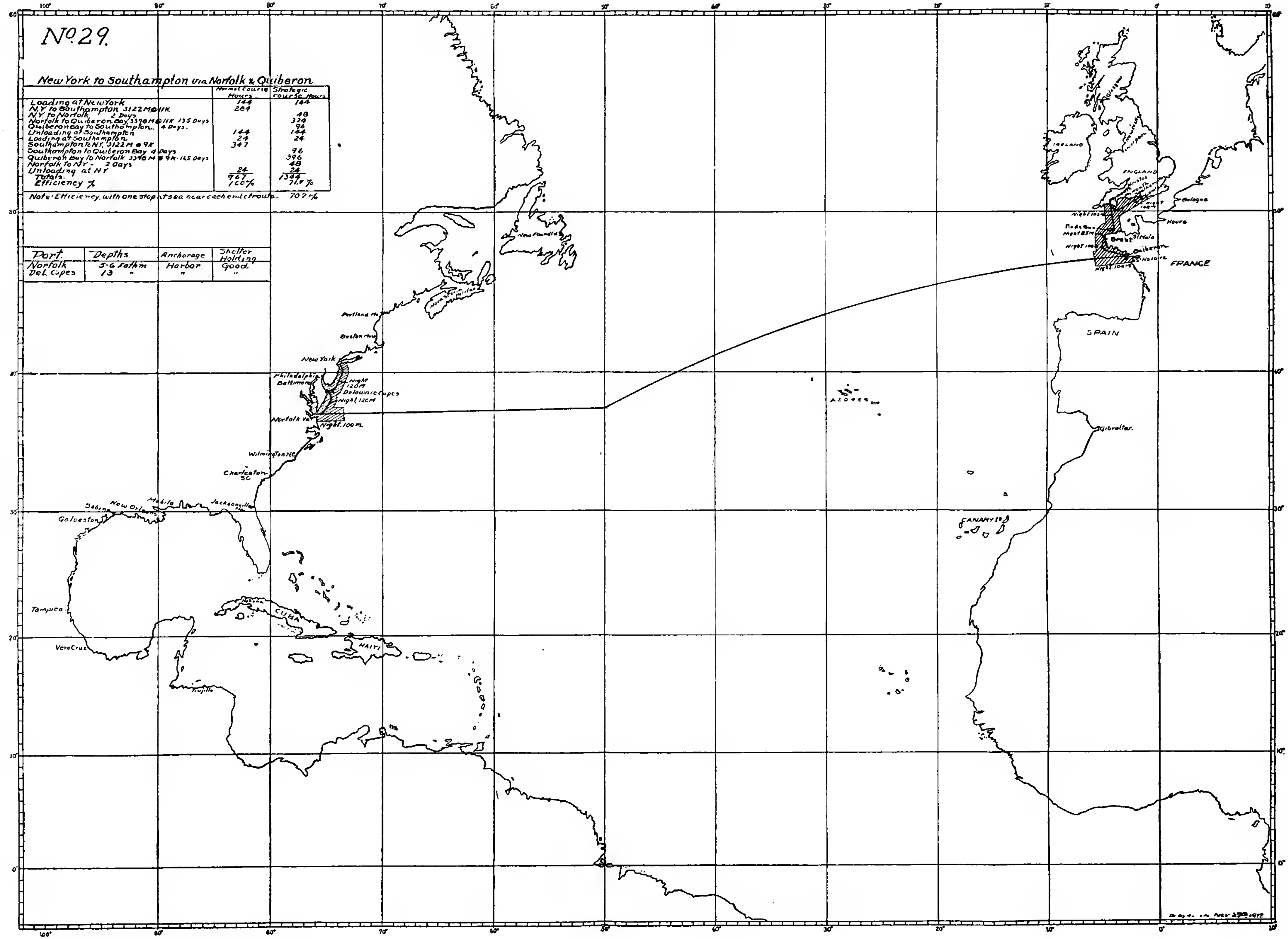
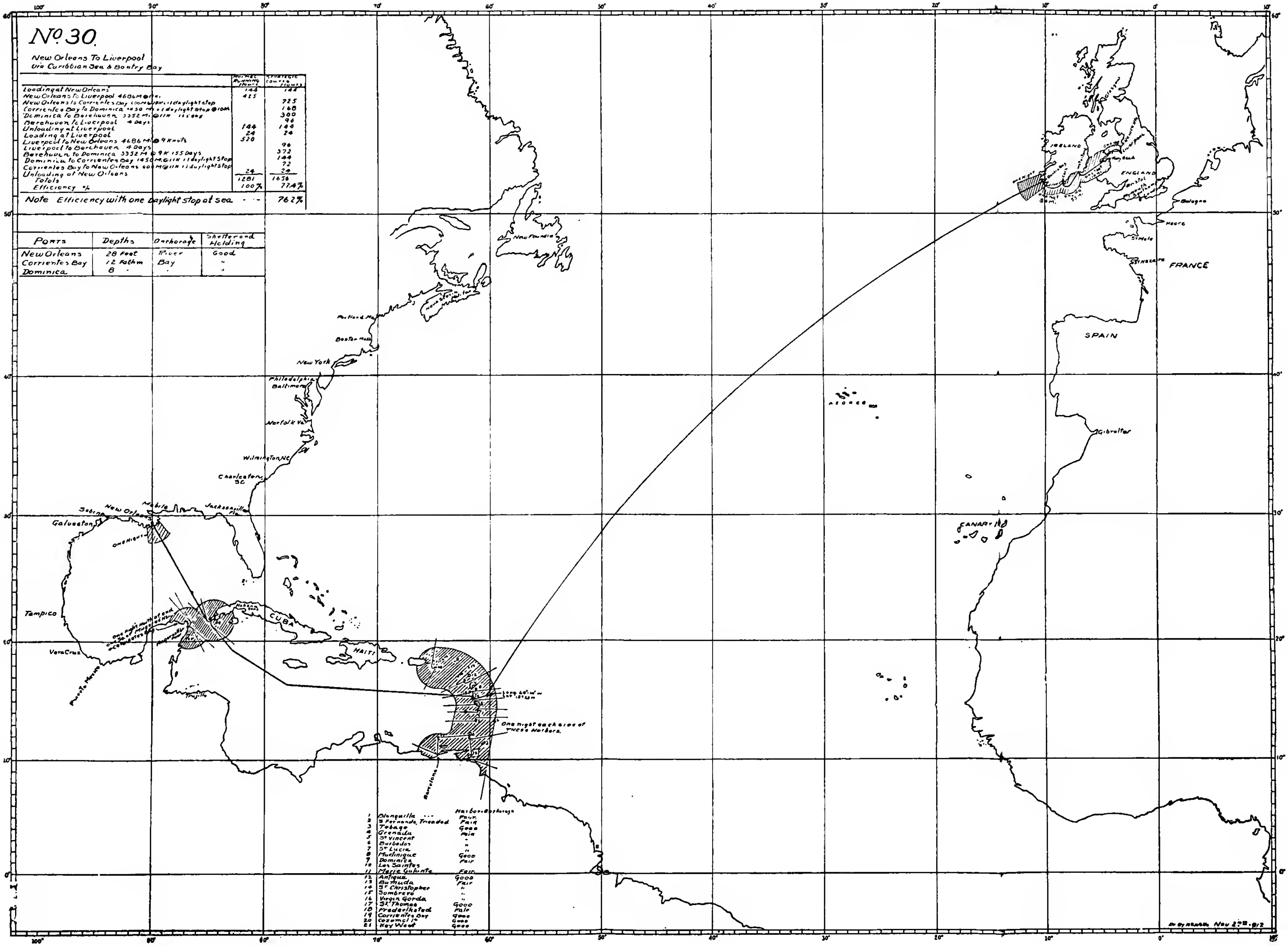


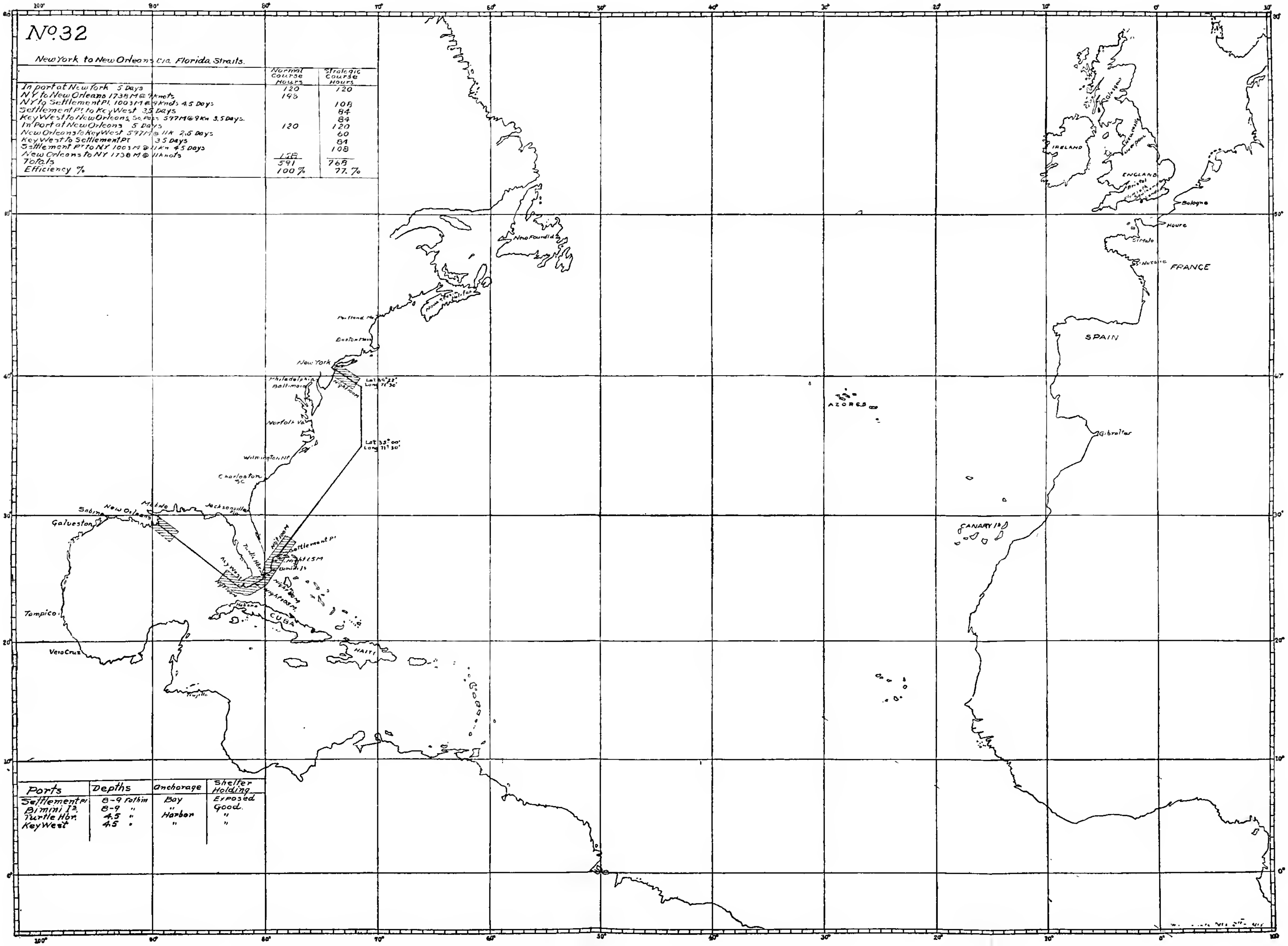
New York to Southampton via Norfolk & Quiberon	Normal course Hours	Strategic course Hours
Loading at New York	144	144
N.Y. to Southampton 3122 M @ 11 K.	284	
N.Y. to Norfolk 2 Days		48
Norfolk to Quiberon Bay 3398 M @ 11 K 13.5 Days		324
Quiberon Bay to Southampton 4 Days.		96
Unloading at Southampton	144	144
Loading at Southampton	24	24
Southampton to N.Y. 3122 M @ 9 K	347	
Southampton to Quiberon Bay 4 Days		96
Quiberon Bay to Norfolk 3398 M @ 9 K 16.5 Days		396
Norfolk to NY - 2 Days		48
Unloading at NY	24	24
Totals.	967	1344
Efficiency %	100%	71.9%

Port.	Depths	Anchorage	Shelter Holding
Norfolk	5-6 Fathm	Harbor	Good
Del. Capes	13 "	"	"

168537°—20. No. 22. (See p. 167.)



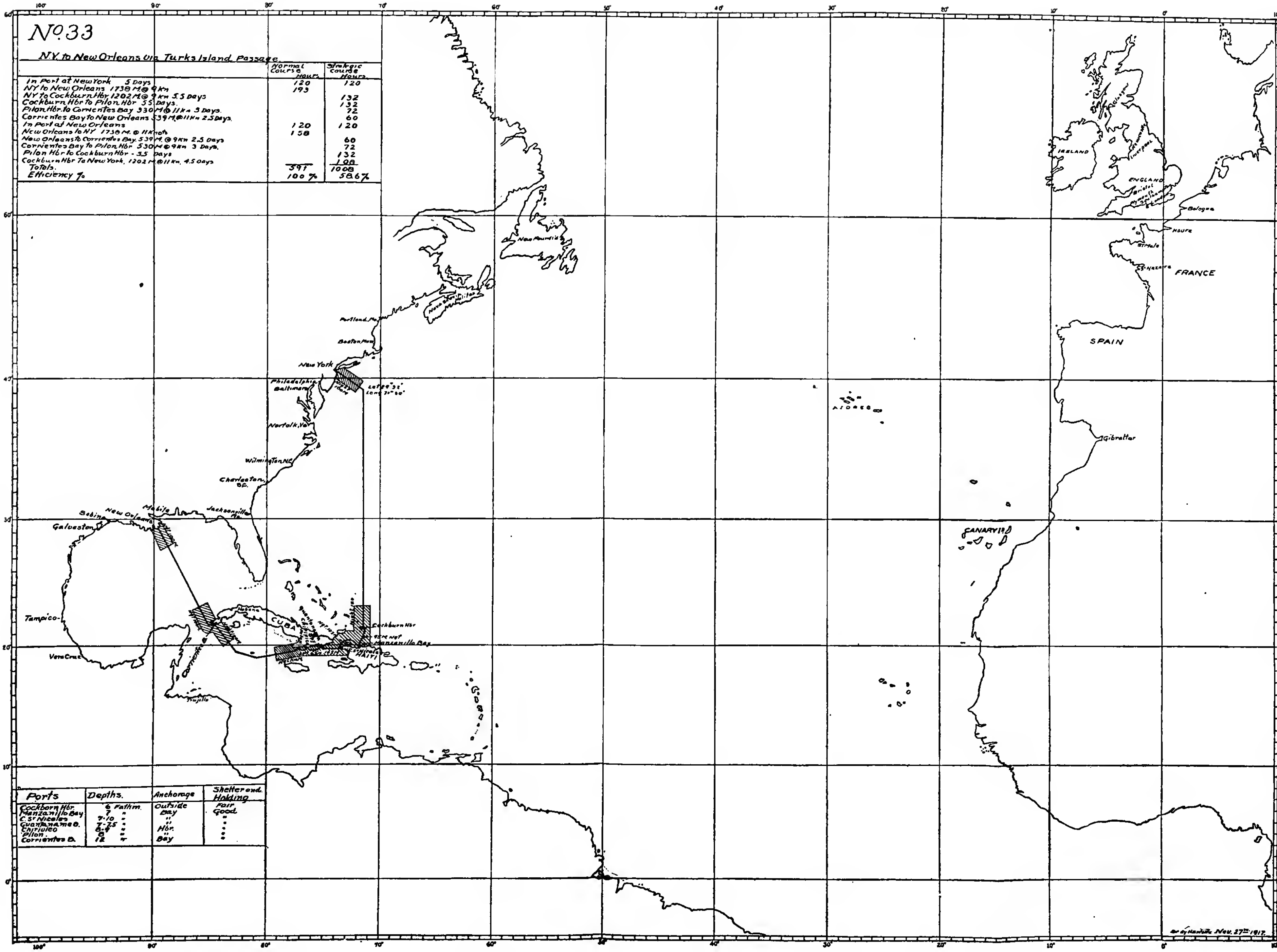
168537°—20. No. 23. (See p. 167.)



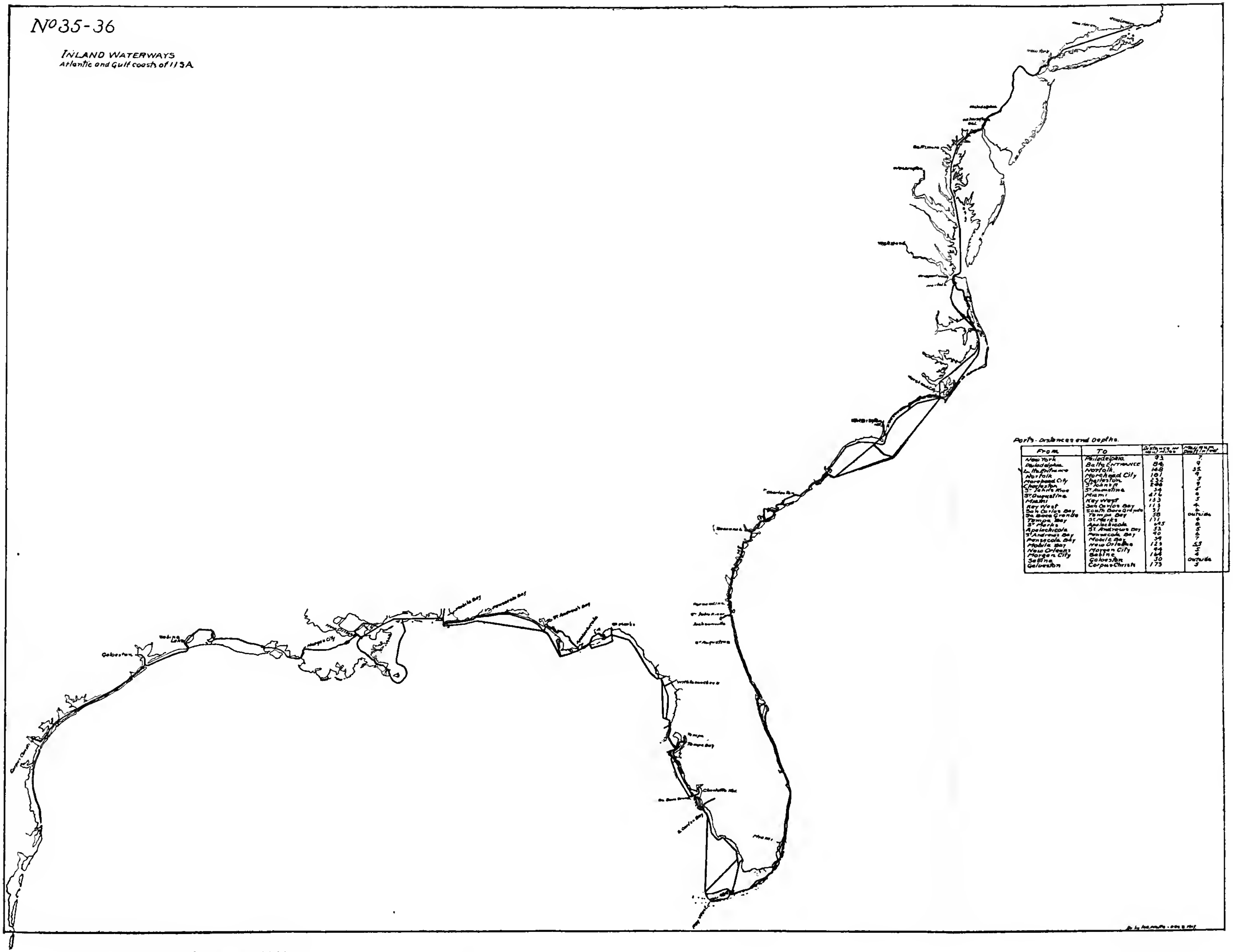
	Normal Course Hours	Strategic Course Hours
In port at New York 5 Days	120	120
N.Y. to New Orleans 1738 M @ 9 knots	193	
N.Y. to Settlement Pt. 1003 M @ 9 knots 4.5 Days		108
Settlement Pt. to Key West 3.5 Days		84
Key West to New Orleans, So. Pass 597 M @ 9 Kn 3.5 Days.		84
In Port at New Orleans 5 Days	120	120
New Orleans to Key West 597 M @ 11 K 2.5 Days		60
Key West to Settlement Pt 3.5 Days		84
Settlement Pt. to N.Y. 1003 M @ 11 Kn 4.5 Days		108
New Orleans to N.Y. 1738 M @ 11 knots	158	
Totals	591	768
Efficiency %	100 %	77.7 %

Ports	Depths	Anchorage	Shelter Holding
Settlement Pt.	8-9 fathom	Bay	Exposed
Bimini Is.	8-9 "	"	Good.
Turtle Hbr.	4.5 "	Harbor	"
Key West	4.5 "	"	"

168537°—20. No. 24. (See p. 167.)



No. 33
N.Y. to New Orleans via Turks Island Passage.
Normal Course Hours
Strategic Course Hours
In Port at New York 5 Days 120 120
NY to New Orleans 1738 M @ 9 Kn 193
NY to Cockburn Hbr 1202 M @ 9 Kn 5.5 Days 132
Cockburn Hbr to Pilon Hbr 5.5 Days. 132
Pilon Hbr. to Corrientes Bay 330 M @ 11 Kn 3 Days. 72
Corrientes Bay to New Orleans 539 M @ 11 Kn 2.5 Days. 60
In Port at New Orleans 120 120
New Orleans to NY 1738 M. @ 11 Knots 158
New Orleans to Corrientes Bay. 539 M. @ 9 Kn 2.5 Days 60
Corrientes Bay to Pilon Hbr 530 M @ 9 Kn 3 Days. 72
Pilon Hbr to Cockburn Hbr - 5.5 Days 132
Cockburn Hbr To New York, 1202 M @ 11 Kn. 4.5 Days 108
Totals. 591 1008
Efficiency % 100 % 58.6%
Ports / Depths. / Anchorage / Shelter and Holding
Cockborn Hbr. 6 Fathm. Outside Fair
Manzanillo Bay 7 " Bay Good
C. St Nicolas 7-10 " " "
Guantanamo B. 7-7.5 " " "
Chiriuico 6-9 " Hbr. "
Pilon. 8 " " "
Corrientes B. 12 " Bay "
IRELAND
ENGLAND
FRANCE
SPAIN
Gibraltar
AZORES
CANARY ID.
CUBA
HAITI
Portland, Me.
Boston, Mass.
New York
Philadelphia
Baltimore
Norfolk, Va.
Wilmington, N.C.
Charleston, S.C.
Jacksonville, Fla.
Mobile
New Orleans
Sabine
Galveston
Tampico
Vera Cruz
Cockburn Hbr
Manzanillo Bay
Havre
Boulogne
St. Nazaire

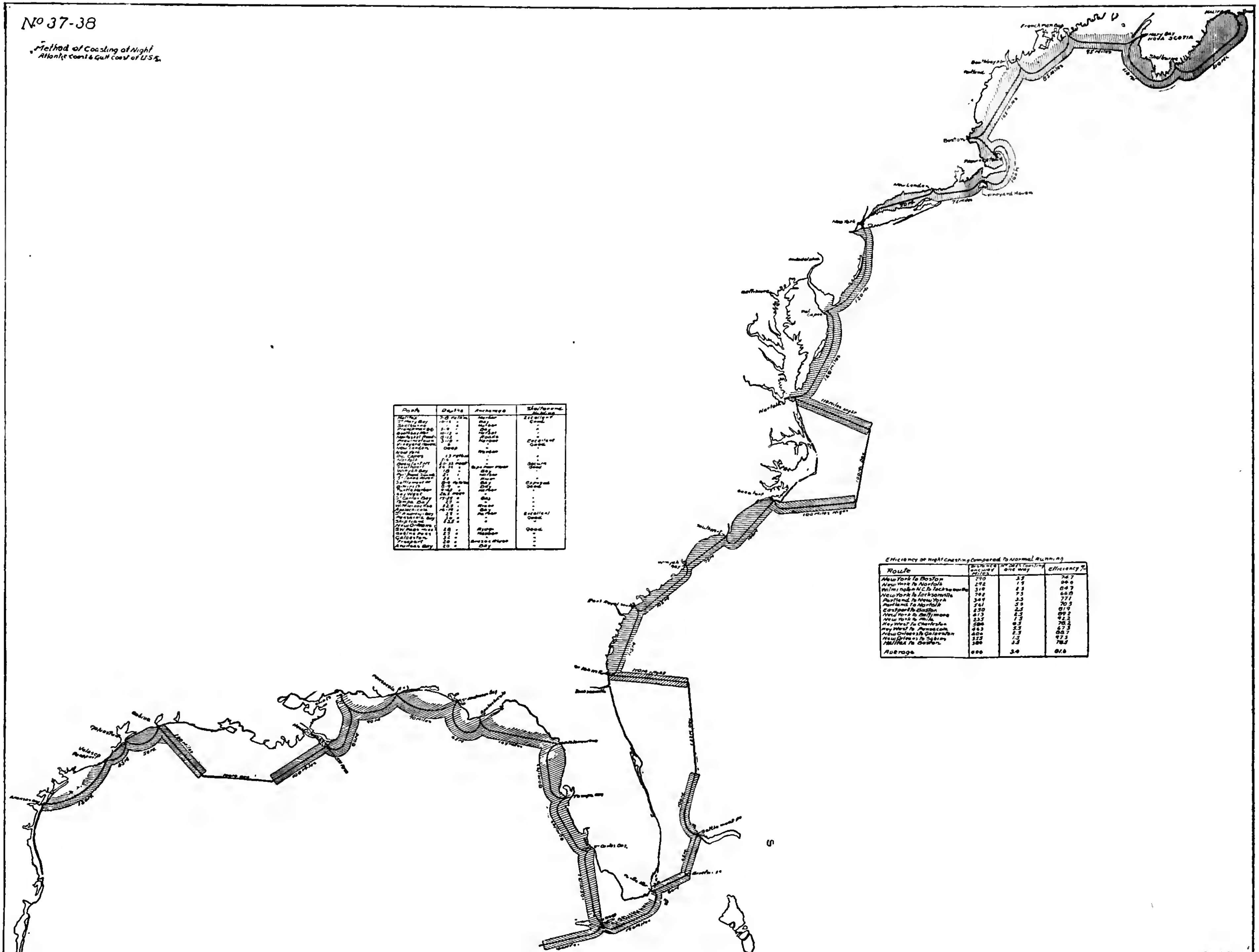


Ports—Distances and Depths.

From	To	Distance in Naut. Miles	Maximum Draft in feet
New York	Philadelphia	93	7
Philadelphia	Balto Entrance	84	9
L. Balto Entrance	Norfolk	148	35
Norfolk	Morehead City	101	9
Morehead City	Charleston	232	5
Charleston	St Johns R.	286	9
St Johns River	St Augustine	34	5
St Augustine	Miami	276	6
Miami	Key West	133	5
Key West	San Carlos Bay	113	4
San Carlos Bay	South Boca Grande	31	6
So. Boca Grande	Tampa Bay	58	Outside
Tampa Bay	St Marks	171	6
St Marks	Apalachicola	145	8
Apalachicola	St Andrews Bay	53	5
St Andrews Bay	Pensacola Bay	90	6
Pensacola Bay	Mobile Bay	39	7
Mobile Bay	New Orleans	123	5.5
New Orleans	Morgan City	94	5
Morgan City	Sabine	164	4
Sabine	Galveston	30	Outside
Galveston	Corpus Christi	173	5

168537°—20. No. 26. (See p. 167.)

No. 37-38



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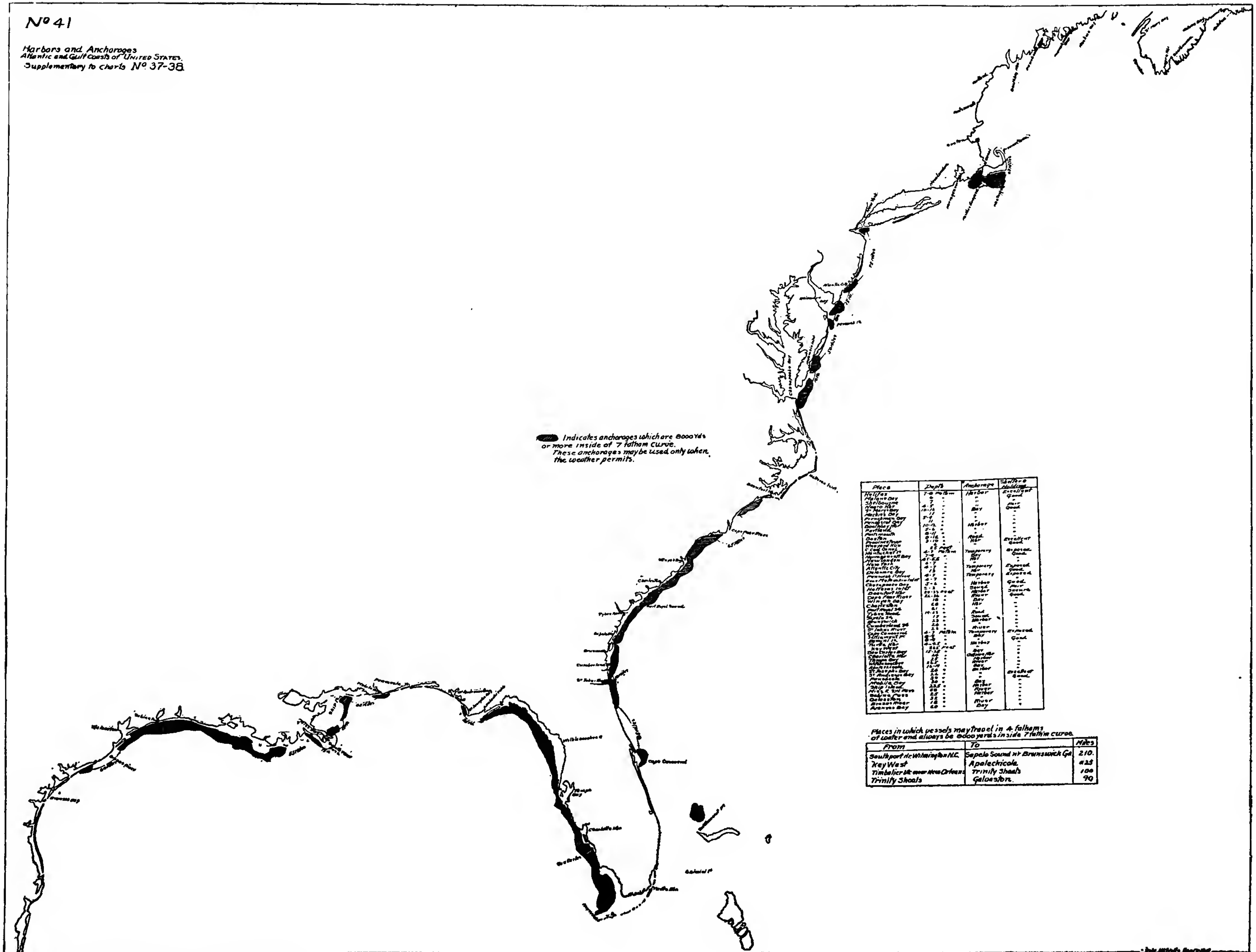
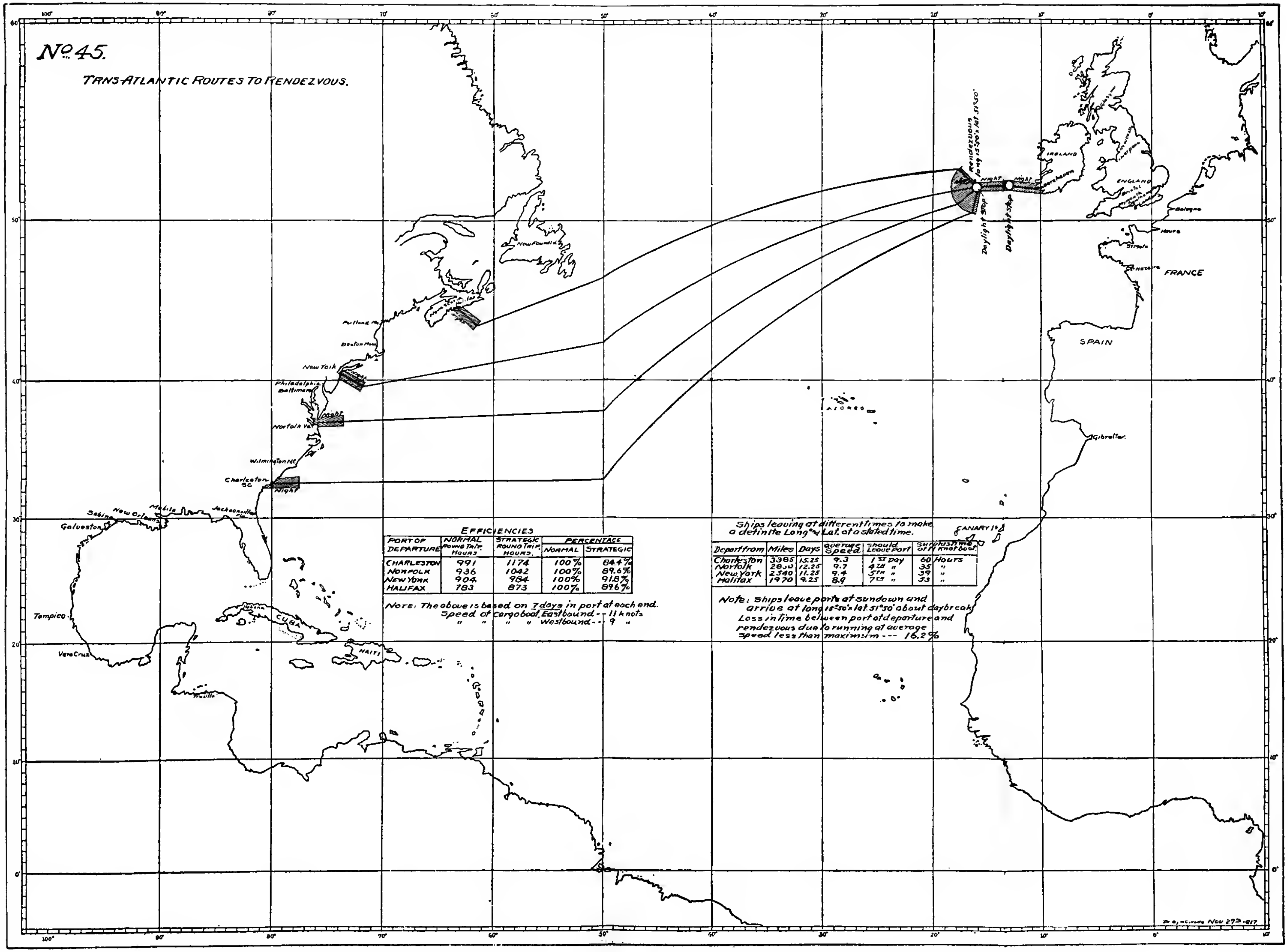


Place	Depth	Anchorage	Shelter & Holding
Halifax	7-8 fathom	Harbor	Excellent
Mahone Bay	6 "	"	Good
Shelbourne	7 "	"	"
Negro Hbr	4-5 "	"	Fair
St Marys Bay	10-12 "	Bay	Good
Machias Bay	11 "	"	"
Frenchman Bay	5-6 "	"	"
Penobscot Bay	11 "	"	"
Boothbay Hbr	10-12 "	Harbor	"
Portland	5-6 "	"	"
Portsmouth	8-11 "	"	"
Boston	8-12 "	Road	"
Provincetown	9-10 "	Hbr	Excellent
Vineyard Hbr	6 "	"	Good
C Cod Canal	25 feet		
Nantucket	4-7 fathom	Temporary	Exposed
Narragansett Bay	7-9 "	Bay	Good
New London	4.5-6.5 "	Hbr	"
New York	6-7 "	"	"
Atlantic City	4-7 "	Temporary	Exposed
Delaware Bay	13 "	Hbr	Good
Fenwick Island	4-7 "	Temporary	Exposed
[illegible] Inlet	4-7 "	"	"
Chesapeake Bay	5-6 "	Harbor	Good
Hatteras Inlet	2-3 "	Sound	Fair
Beaufort Hbr	20-35 feet	Harbor	Secure
Cape Fear River	21-36 "	River	Good
Winyah Bay	18 "	Bay	"
Charleston	28 "	Hbr	"
Port Royal Sd	21 "	"	"
Tybee Sound	19-21 "	Road	"
Sapelo Sd	17 "	Sound	"
Brunswick	23 "	Harbor	"
Cumberland Sd	24 "	"	"
St Johns River	21 "	River	"
Cape Canaveral	4-7 fathom	Temporary	Exposed
Settlement Pt	[illegible] "	Bay	"
Bimini Is	[illegible] "	"	Good
Turtle Hbr	4-4.5 "	Harbor	"
Key West	36 feet	"	"
[illegible] Bay	15-36 "	Bay	"
Charlotte Hbr	26 "	[illegible] Hbr	"
Tampa Bay	23 "	Harbor	"
[illegible]	25.5 "	River	"
Apalachicola	16-19 "	Bay	"
St Josephs Bay	24 "	Harbor	"
St Andrews Bay	24 "	"	Excellent
Pensacola	30 "	"	Good
Mobile Bay	30 "	Bay	"
Ship Island	23.5 "	Harbor	"
Miss R SW Pass	60 "	River	"
Sabine Pass	25 "	Harbor	"
Galveston	32 "	"	"
Brazos River	18 "	River	"
Aransas Bay	60 "	Bay	"

Places in which vessels may travel in 4 fathoms of water and always be 6000 yards inside 7 fathom curve.

From	To	Miles
Southport nr Wilmington N.C.	Sapelo Sound nr Brunswick Ga	210.
Key West	Apalachicola	425
Timbalier Lt near New Orleans	Trinity Shoals	100
Trinity Shoals	Galveston.	90

168537°—20. No. 28. (See p. 167.)



EFFICIENCIES

PORT OF DEPARTURE	NORMAL ROUND TRIP. HOURS	STRATEGIC ROUND TRIP. HOURS.	PERCENTAGE NORMAL	PERCENTAGE STRATEGIC
CHARLESTON	991	1174	100%	84.4%
NORFOLK	936	1042	100%	89.6%
NEW YORK	904	984	100%	91.8%
HALIFAX	783	873	100%	89.6%

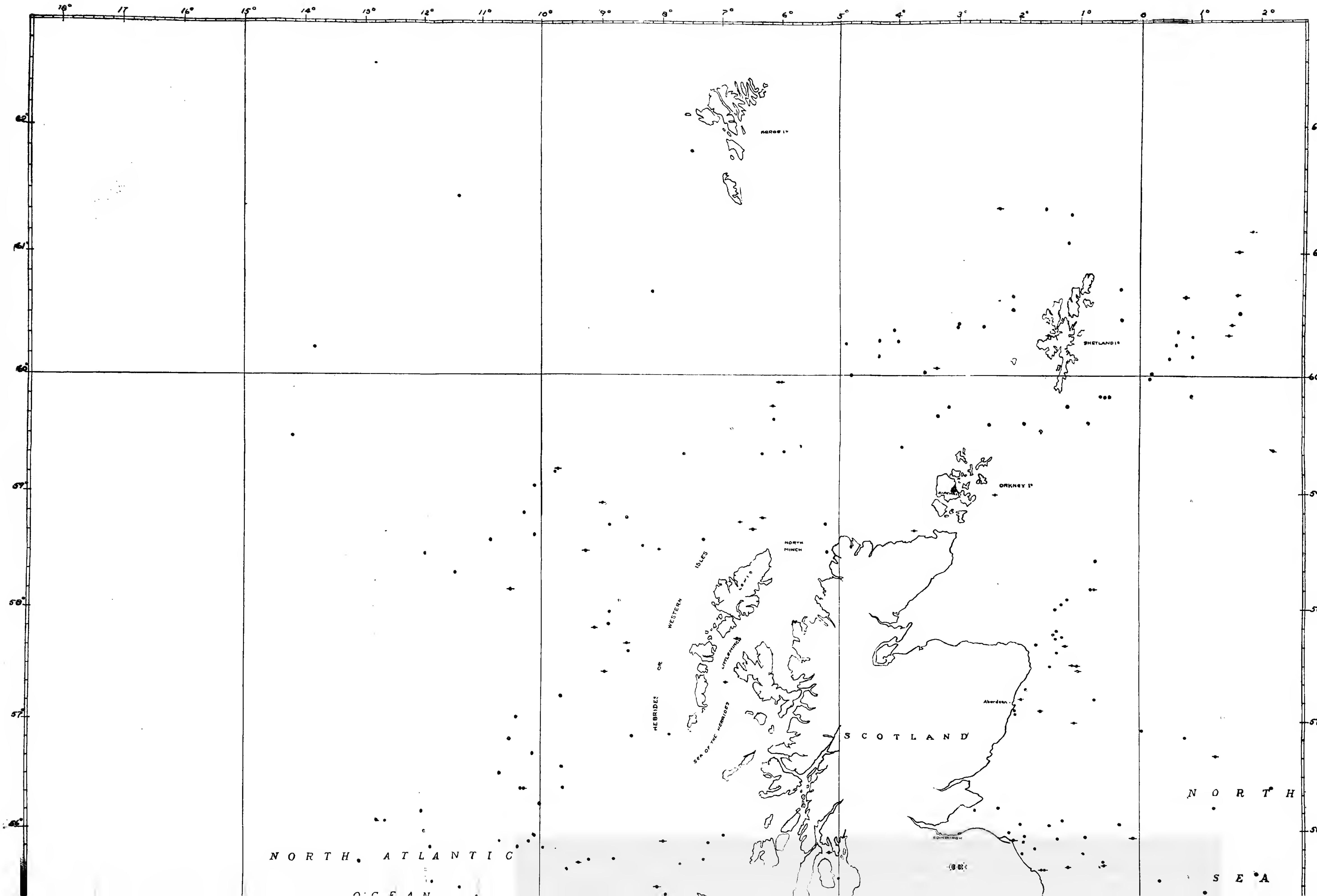
NOTE: The above is based on 7 days in port at each end.
Speed of cargoboat, Eastbound -- 11 knots
" " " " Westbound -- 9 "

Ships leaving at different times to make a definite Long. & Lat. at a stated time.

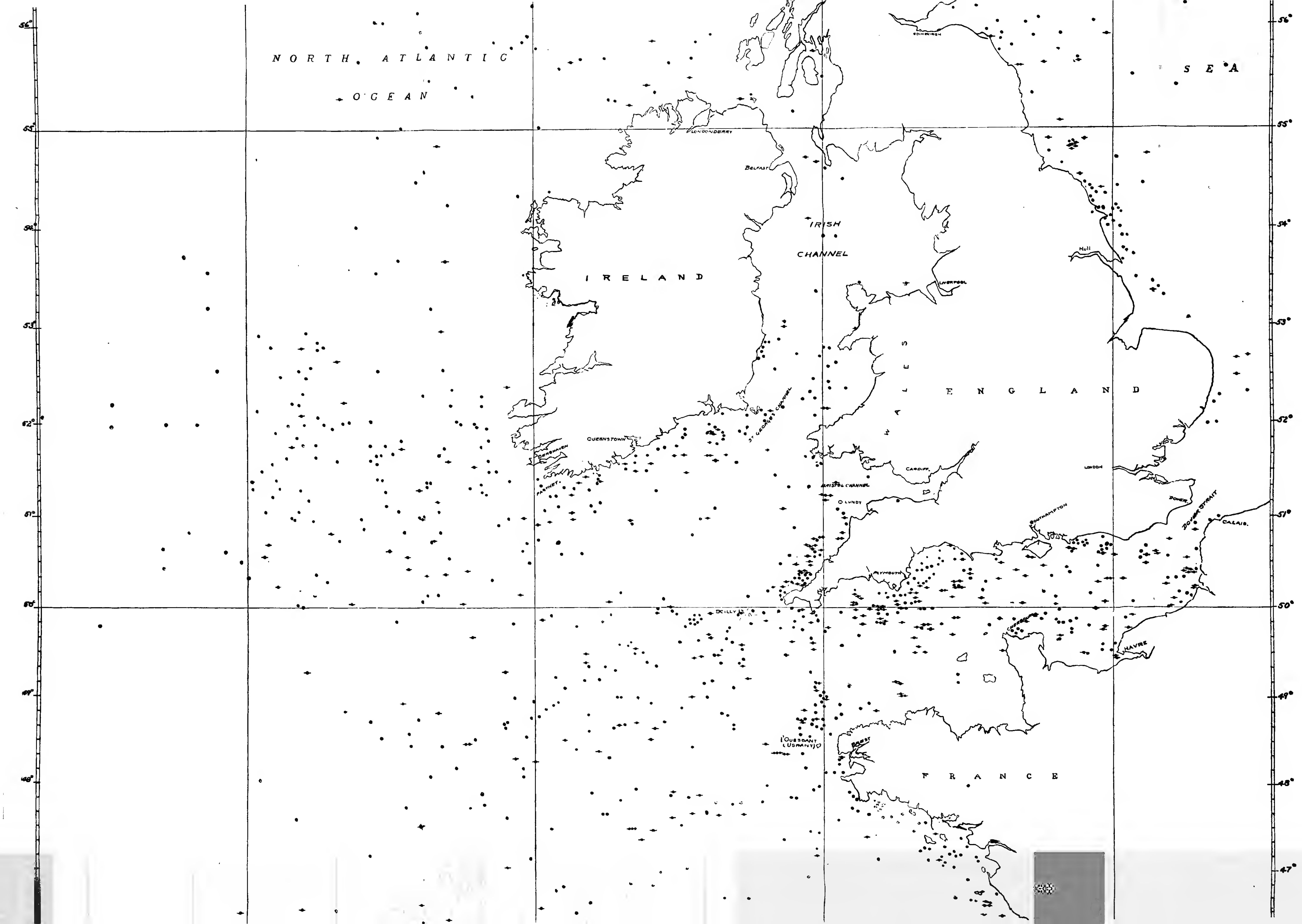
Depart from	Miles	Days	average Speed	should Leave Port	Surplus time of 11 knot boat
Charleston	3385	15.25	9.3	1st Day	60 Hours
Norfolk	2850	12.25	9.7	4th "	35 "
New York	2540	11.25	9.4	5th "	39 "
Halifax	1970	9.25	8.9	7th "	53 "

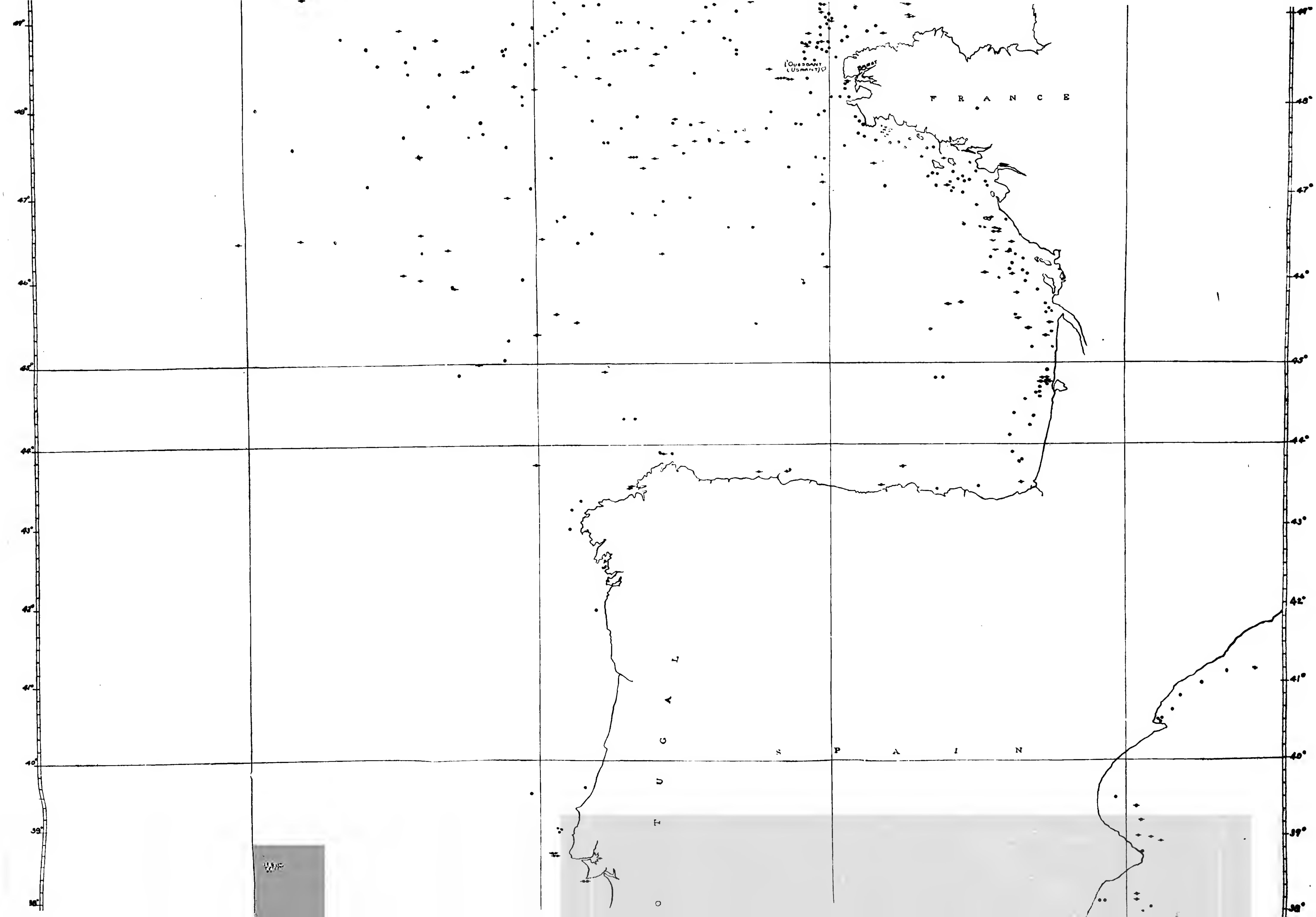
Note: Ships leave ports at sundown and arrive at long 15°50' x lat. 51°50' about daybreak.
Loss in time between port of departure and rendezvous due to running at average speed less than maximum --- 16.2%

168537°—20. No. 30. (See p. 167.)

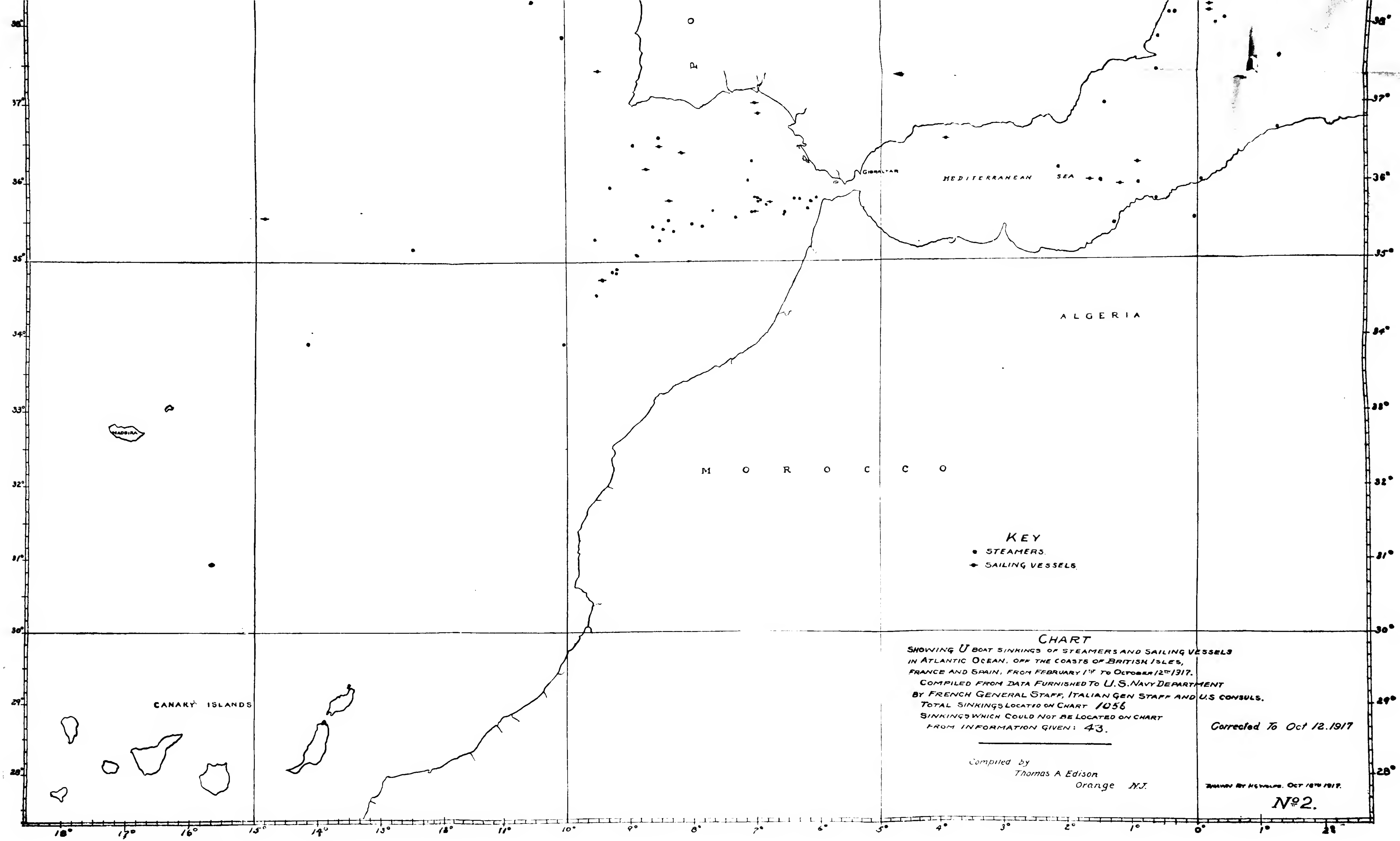


FAROE Iˢ
SHETLAND Iˢ
ORKNEY Iˢ
NORTH MINCH
HEBRIDES OR WESTERN ISLES
LEWIS
LITTLE MINCH
SEA OF THE HEBRIDES
SCOTLAND
Aberdeen
NORTH ATLANTIC
NORTH
SEA

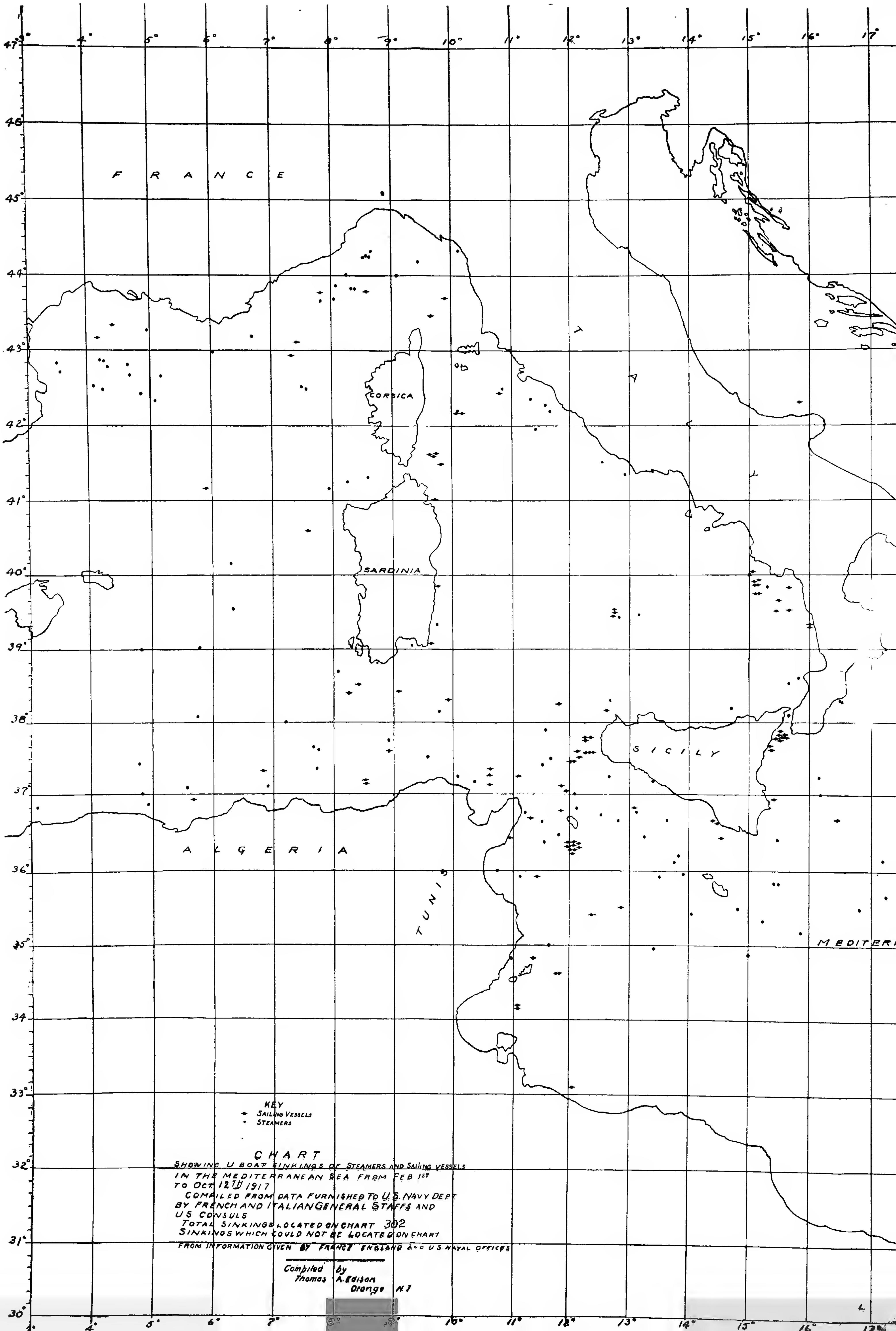

NORTH ATLANTIC
OCEAN
SEA
IRELAND
IRISH
CHANNEL
WALES
ENGLAND
FRANCE
LONDONDERRY
BELFAST
LIVERPOOL
Hull
QUEENSTOWN
ST GEORGE'S CHANNEL
CARDIFF
BRISTOL CHANNEL
LUNDY
LONDON
DOVER
DOVER STRAIT
CALAIS
SOUTHAMPTON
PLYMOUTH
HAVRE
BREST
56°
55°
54°
53°
52°
51°
50°
49°
48°
47°



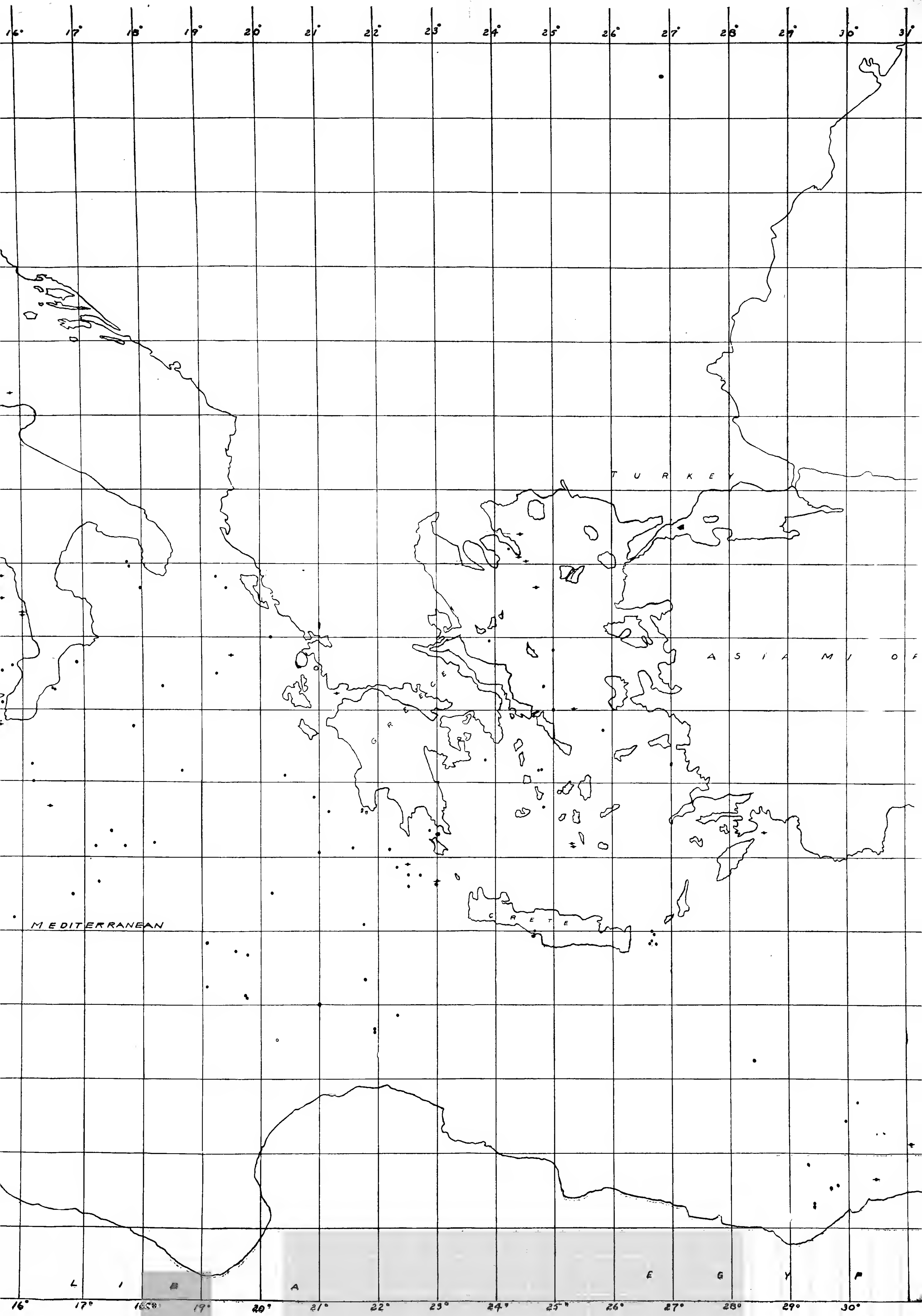
F R A N C E
S P A I N
OUESSANT (USHANT)
49°
48°
47°
46°
45°
44°
43°
42°
41°
40°
39°
38°



168537°—20. No. 2. (See p. 167.)



168537°—20, No. 21. (See p. 167.)



16°
17°
18°
19°
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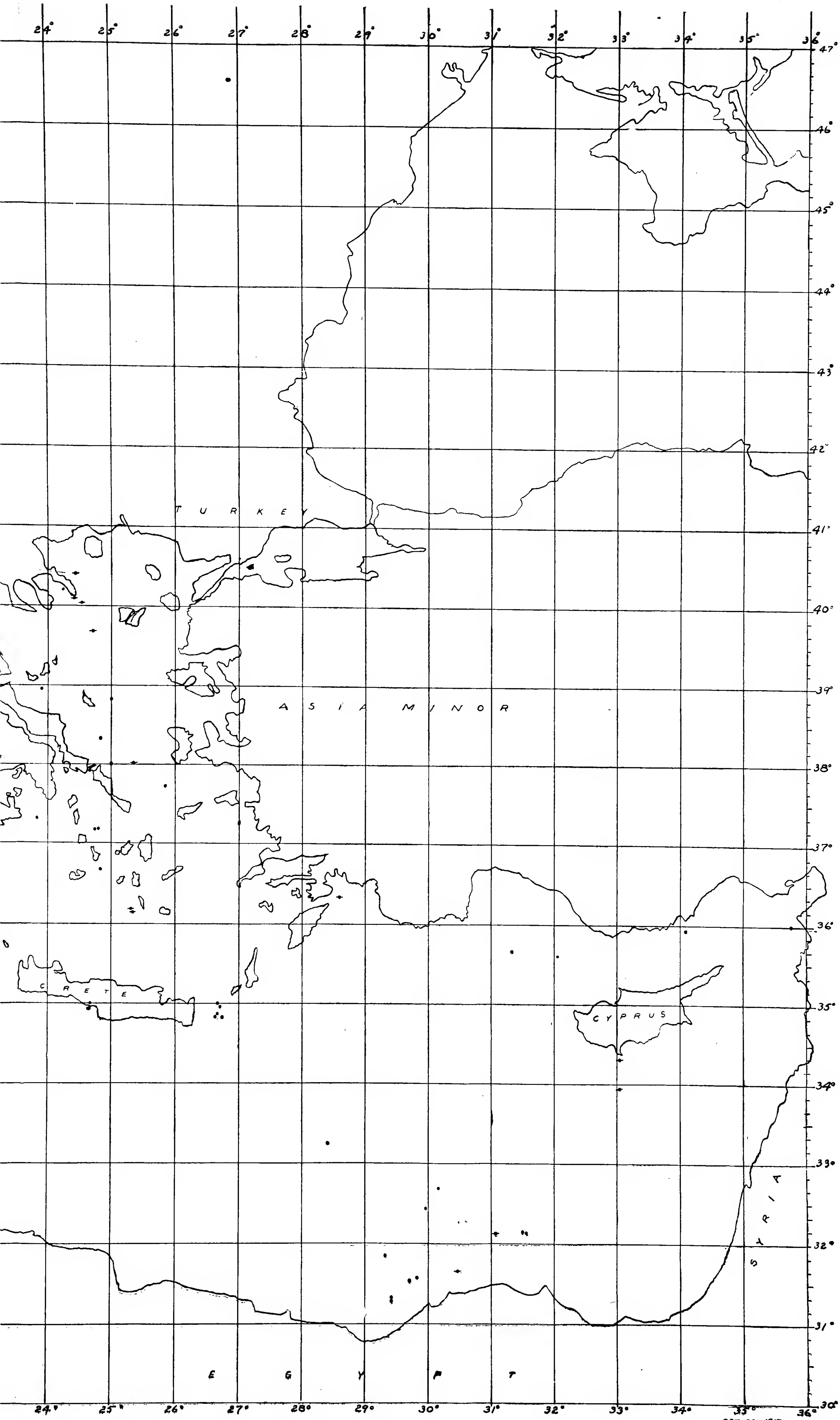
21°
22°
23°
24°
25°
26°
27°
28°
29°
30°
31°
T U R K E Y
A S I A M I N O R
G R E E C E
C R E T E
M E D I T E R R A N E A N
L I B Y A
E G Y P T



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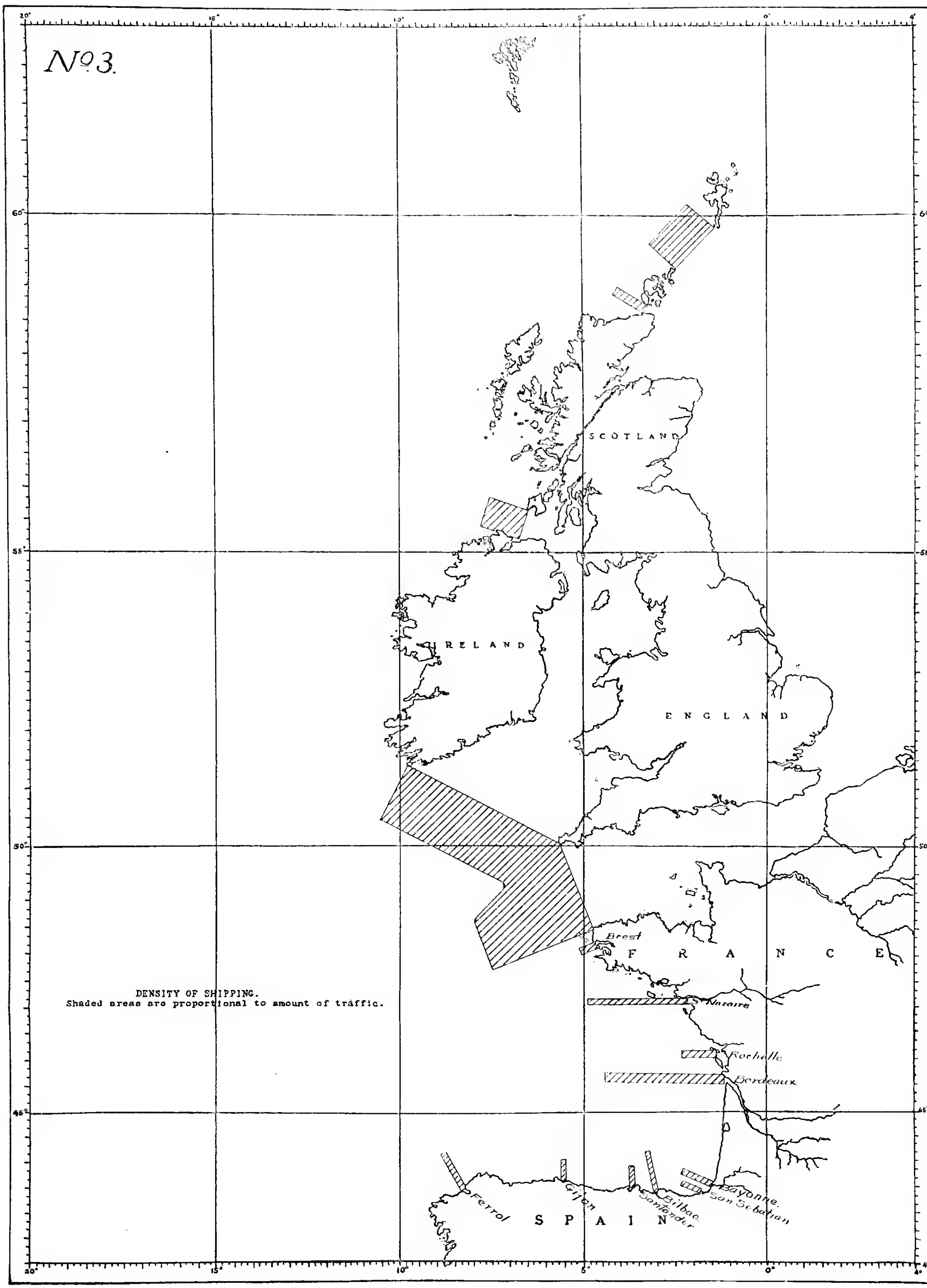
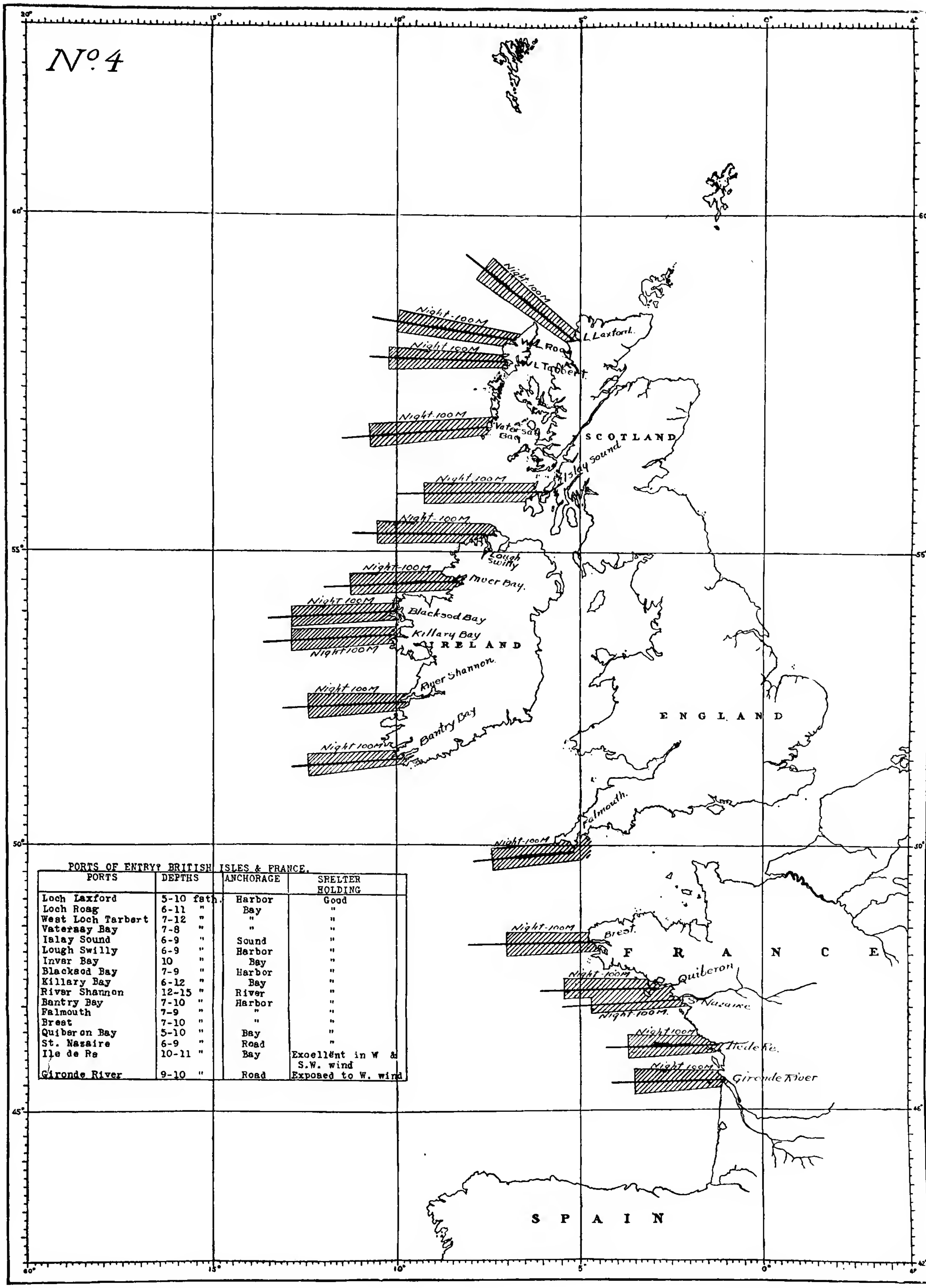
H.C.WOLFE.



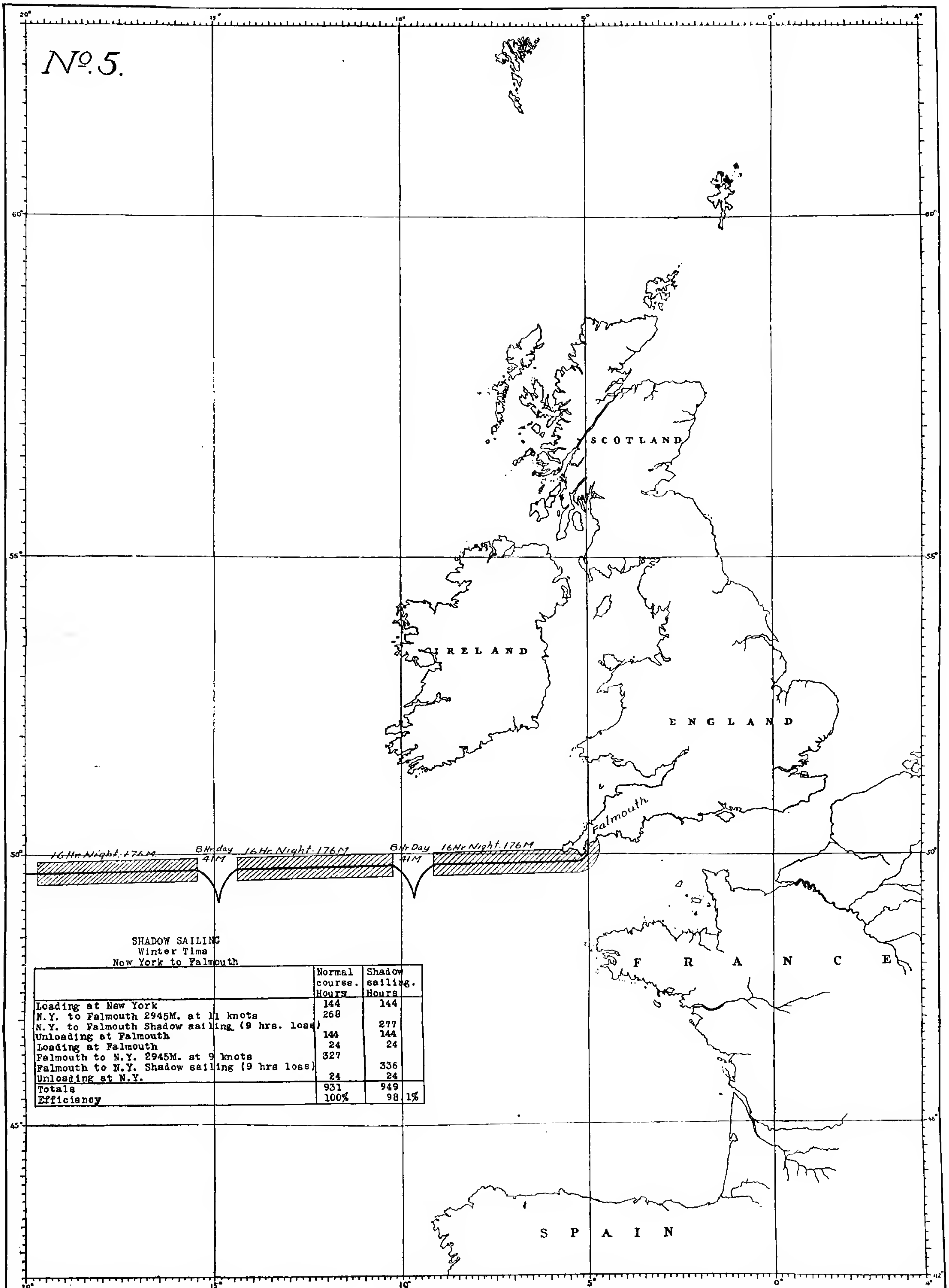
168537°—20. No. 3. (See p. 167.)



PORTS OF ENTRY? BRITISH ISLES & FRANCE.

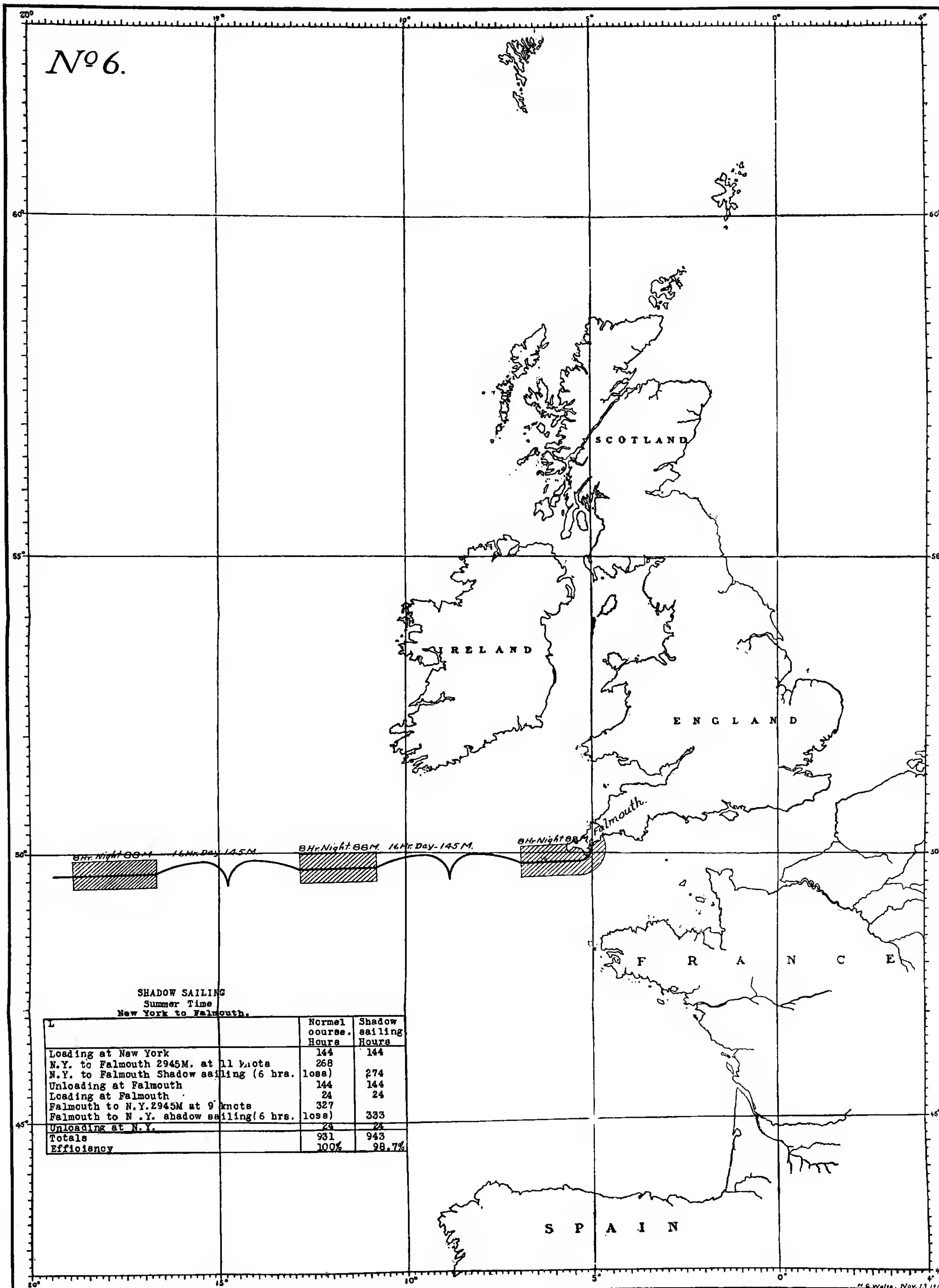
PORTS	DEPTHS	ANCHORAGE	SHELTER HOLDING
Loch Laxford	5-10 fath.	Harbor	Good
Loch Roag	6-11 "	Bay	"
West Loch Tarbert	7-12 "	"	"
Vatersay Bay	7-8 "	"	"
Islay Sound	6-9 "	Sound	"
Lough Swilly	6-9 "	Harbor	"
Inver Bay	10 "	Bay	"
Blacksod Bay	7-9 "	Harbor	"
Killary Bay	6-12 "	Bay	"
River Shannon	12-15 "	River	"
Bantry Bay	7-10 "	Harbor	"
Falmouth	7-9 "	"	"
Brest	7-10 "	"	"
Quiberon Bay	5-10 "	Bay	"
St. Nazaire	6-9 "	Road	"
Ile de Re	10-11 "	Bay	Excellent in W & S.W. wind
Gironde River	9-10 "	Road	Exposed to W. wind

168537°—20. No. 4. (See p. 167.)



SHADOW SAILING
Winter Time
New York to Falmouth

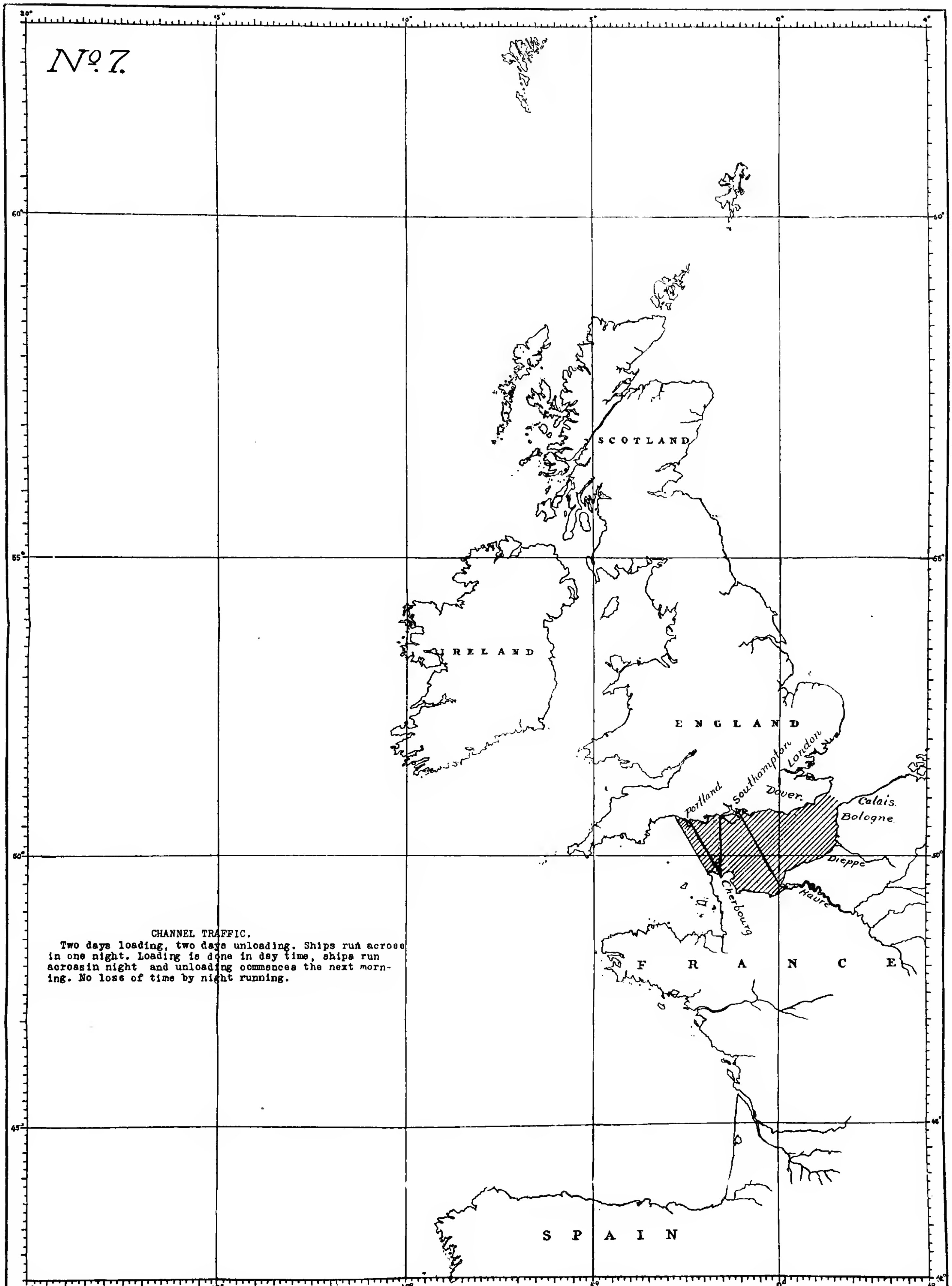
	Normal course. Hours	Shadow sailing. Hours
Loading at New York	144	144
N.Y. to Falmouth 2945M. at 11 knots	268	
N.Y. to Falmouth Shadow sailing (9 hrs. loss)		277
Unloading at Falmouth	144	144
Loading at Falmouth	24	24
Falmouth to N.Y. 2945M. at 9 knots	327	
Falmouth to N.Y. Shadow sailing (9 hrs loss)		336
Unloading at N.Y.	24	24
Totals	931	949
Efficiency	100%	98.1%



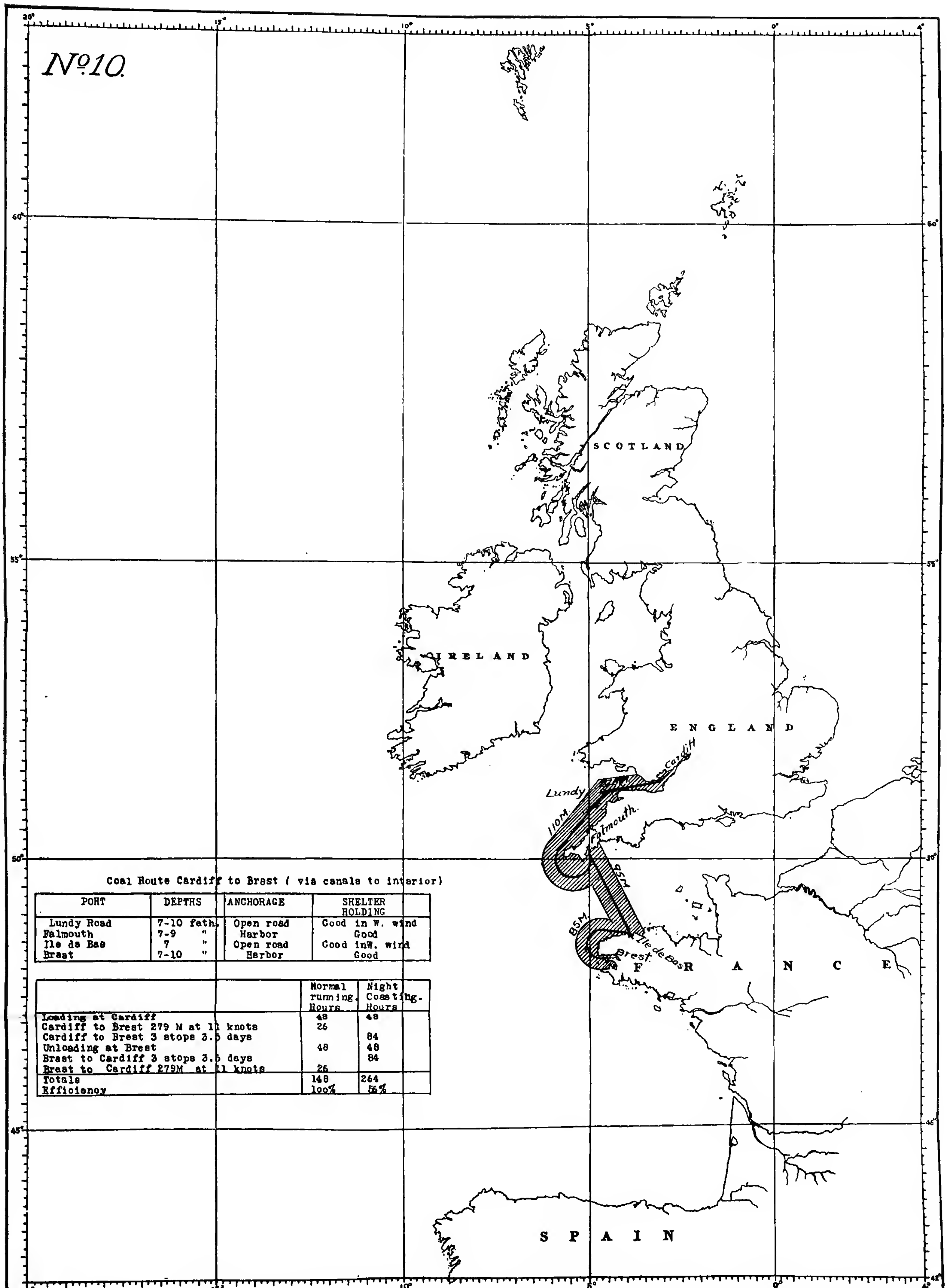
SHADOW SAILING
Summer Time
New York to Falmouth.

L	Normel oourse. Hours	Shadow sailing Hours
Loading at New York	144	144
N.Y. to Falmouth 2945M. at 11 knots	268	
N.Y. to Falmouth Shadow sailing (6 hrs. loss)		274
Unloading at Falmouth	144	144
Loading at Falmouth	24	24
Falmouth to N.Y. 2945M at 9 knots	327	
Falmouth to N.Y. shadow sailing (6 hrs. loss)		333
Unloading at N.Y.	24	24
Totals	931	943
Efficiancy	100%	98.7%

168537°—20. No. 6. (See p. 167.)



168537°—20. No. 7. (See p. 167.)

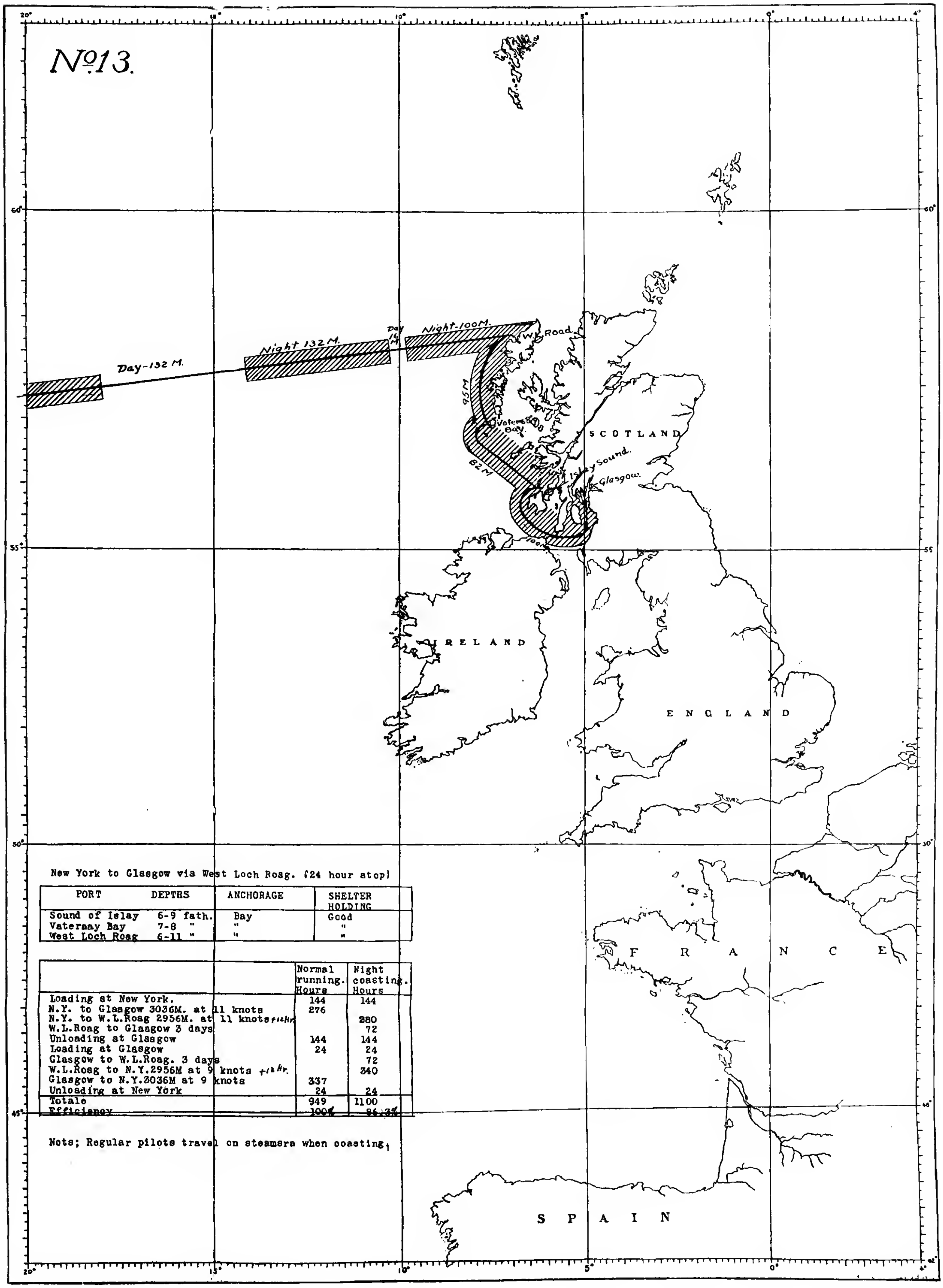


Coal Route Cardiff to Brest (via canals to interior)

PORT	DEPTHS	ANCHORAGE	SHELTER HOLDING
Lundy Road	7-10 fath.	Open road	Good in W. wind
Falmouth	7-9 "	Harbor	Good
Ile de Bas	7 "	Open road	Good inW. wind
Brest	7-10 "	Harbor	Good

	Normal running. Hours	Night Coasting. Hours
Loading at Cardiff	48	48
Cardiff to Brest 279 M at 11 knots	26	
Cardiff to Brest 3 stops 3.5 days		84
Unloading at Brest	48	48
Brest to Cardiff 3 stops 3.5 days		84
Brest to Cardiff 279M at 11 knots	26	
Totals	148	264
Efficiency	100%	56%

 (See p. 167.)

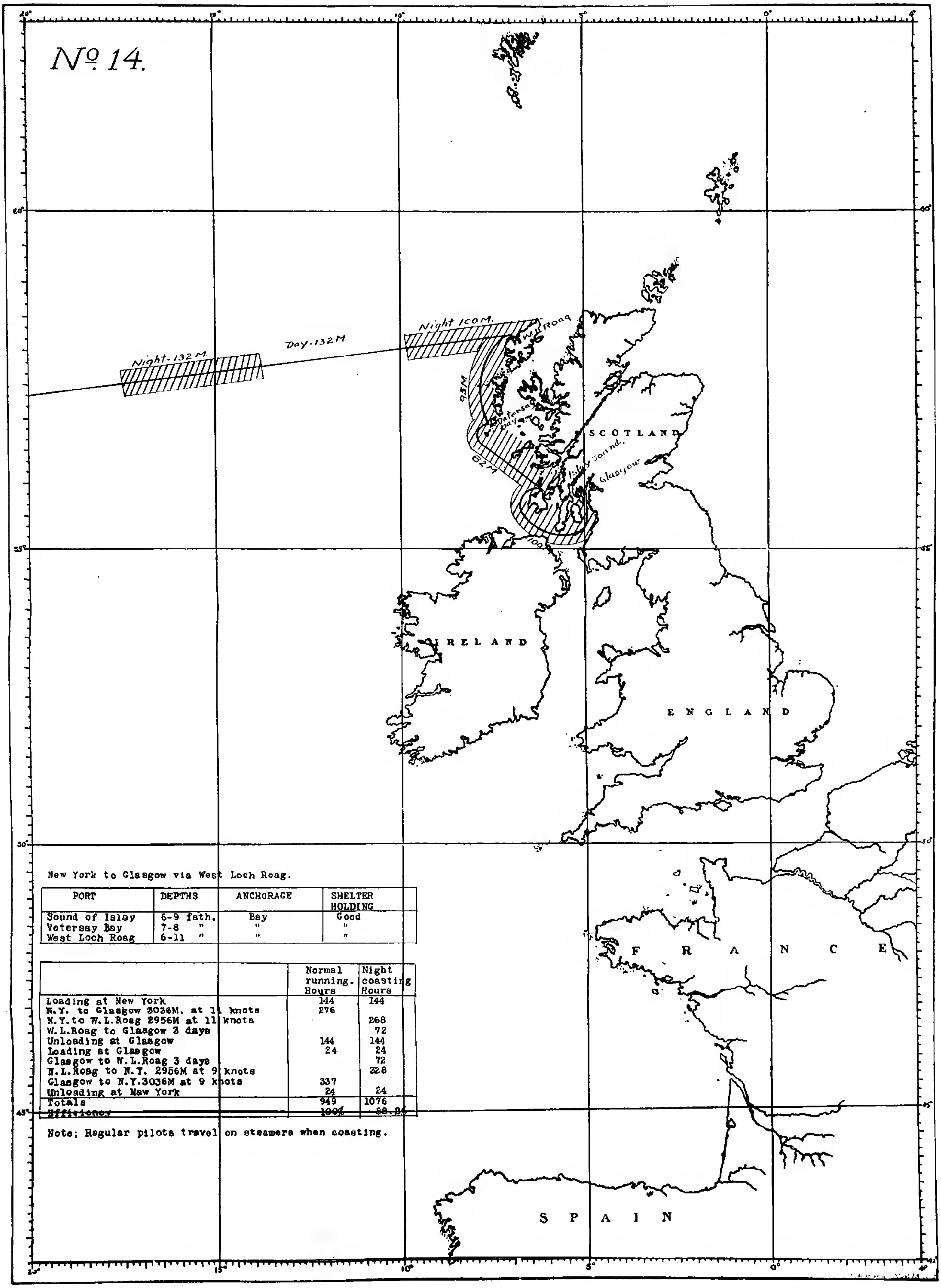


New York to Glasgow via West Loch Roag. (24 hour stop)

PORT	DEPTRS	ANCHORAGE	SHELTER HOLDING
Sound of Islay	6-9 fath.	Bay	Good
Vatersay Bay	7-8 "	"	"
West Loch Roag	6-11 "	"	"

	Normal running. Hours	Night coasting. Hours
Loading at New York.	144	144
N.Y. to Glasgow 3036M. at 11 knots	276	
N.Y. to W.L.Roag 2956M. at 11 knots +12Hr		280
W.L.Roag to Glasgow 3 days		72
Unloading at Glasgow	144	144
Loading at Glasgow	24	24
Glasgow to W.L.Roag. 3 days		72
W.L.Roag to N.Y.2956M at 9 knots +12 Hr.		340
Glasgow to N.Y.3036M at 9 knots	337	
Unloading at New York	24	24
Totals	949	1100
Efficiency	100%	86.3%

Note; Regular pilots travel on steamers when coasting.



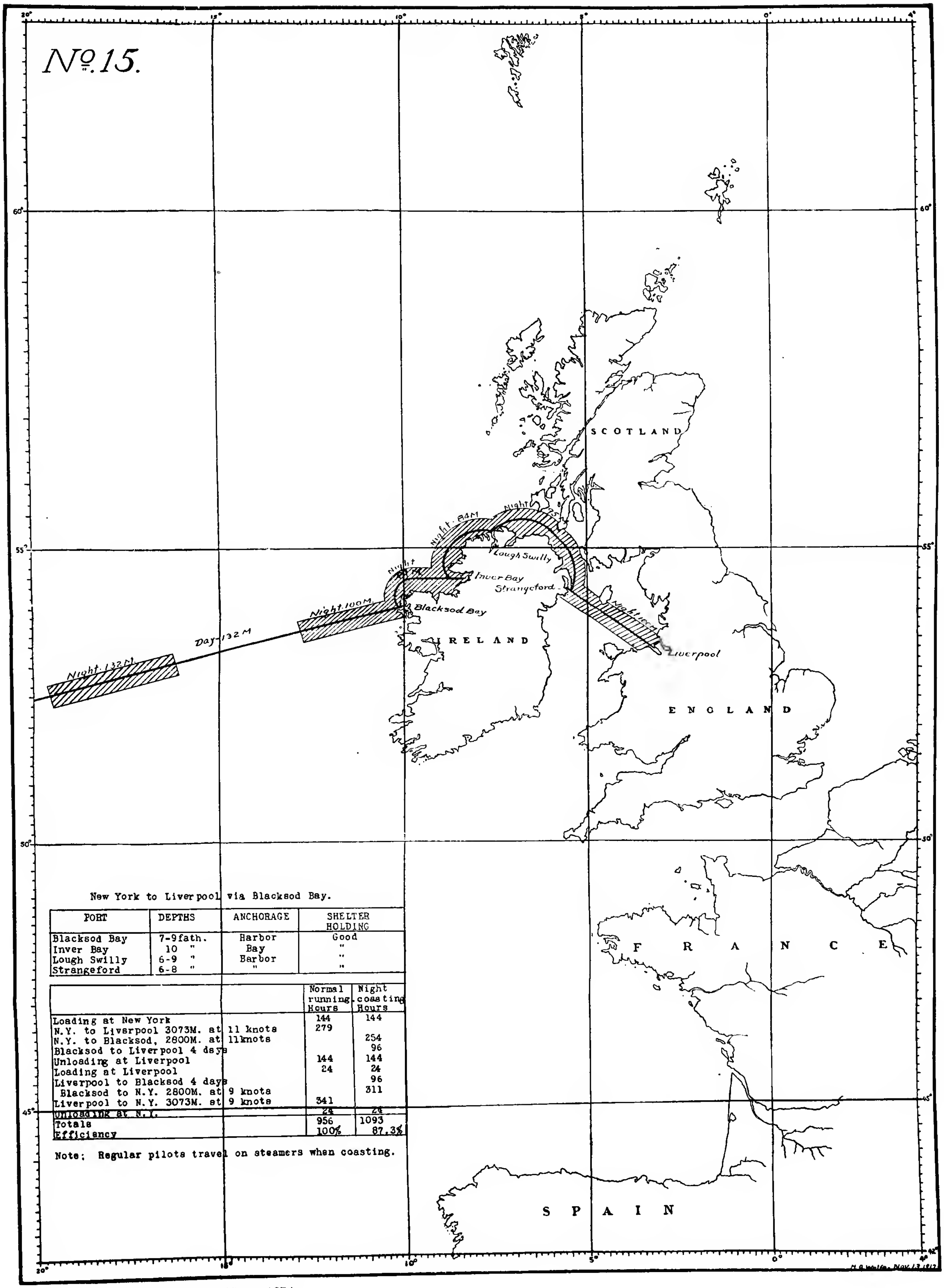
New York to Glasgow via West Loch Roag.

PORT	DEPTHS	ANCHORAGE	SHELTER HOLDING
Sound of Islay	6-9 fath.	Bay	Good
Votersay Bay	7-8 "	"	"
West Loch Roag	6-11 "	"	"

	Normal running. Hours	Night coasting Hours
Loading at New York	144	144
N.Y. to Glasgow 3036M. at 11 knots	276	
N.Y.to W.L.Roag 2956M at 11 knots		268
W.L.Roag to Glasgow 3 days		72
Unloading at Glasgow	144	144
Loading at Glasgow	24	24
Glasgow to W.L.Roag 3 days		72
W.L.Roag to N.Y. 2956M at 9 knots		328
Glasgow to N.Y.3036M at 9 knots	337	
Unloading at New York	24	24
Totals	949	1076
Efficiency	100%	88.8%

Note; Regular pilots travel on steamers when coasting.

 (See p. 167.)



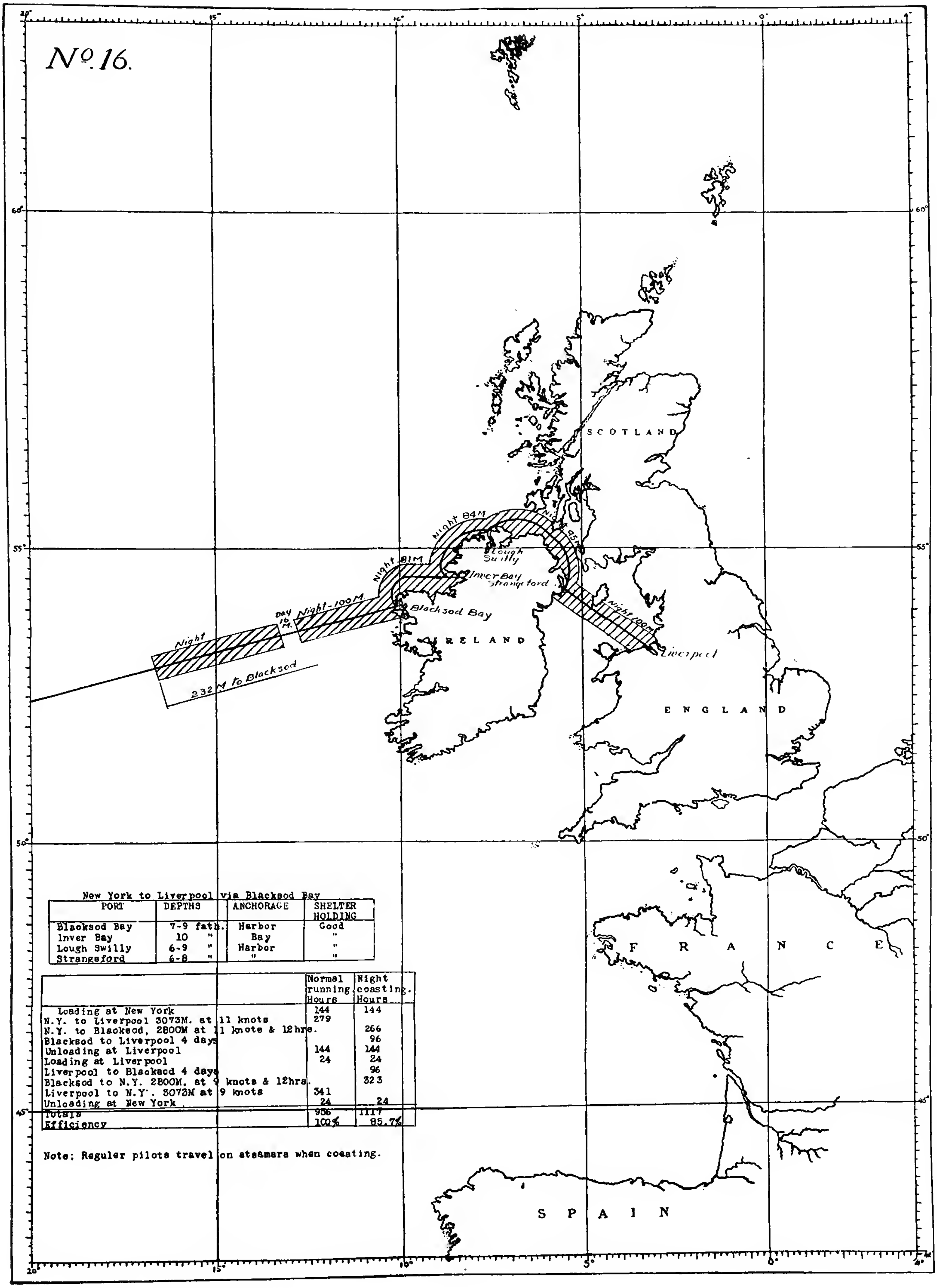
New York to Liverpool via Blacksod Bay.

PORT	DEPTHS	ANCHORAGE	SHELTER HOLDING
Blacksod Bay	7-9 fath.	Harbor	Good
Inver Bay	10 "	Bay	"
Lough Swilly	6-9 "	Harbor	"
Strangeford	6-8 "	"	"

	Normal running Hours	Night coasting Hours
Loading at New York	144	144
N.Y. to Liverpool 3073M. at 11 knots	279	
N.Y. to Blacksod, 2800M. at 11 knots		254
Blacksod to Liverpool 4 days		96
Unloading at Liverpool	144	144
Loading at Liverpool	24	24
Liverpool to Blacksod 4 days		96
Blacksod to N.Y. 2800M. at 9 knots		311
Liverpool to N.Y. 3073M. at 9 knots	341	
Unloading at N.Y.	24	24
Totals	956	1093
Efficiency	100%	87.3%

Note: Regular pilots travel on steamers when coasting.

 (See p. 167.)



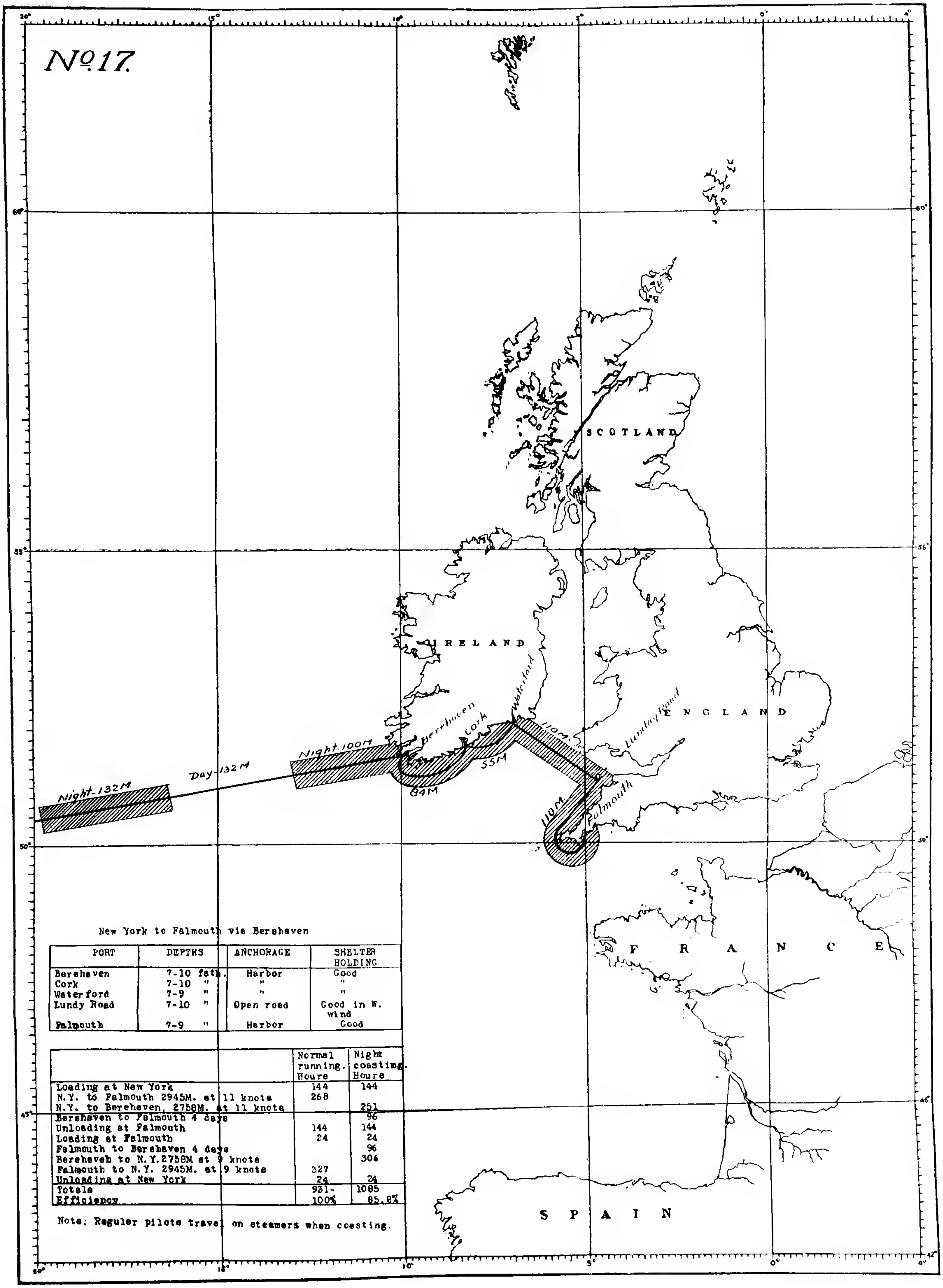
New York to Liverpool via Blacksod Bay

PORT	DEPTHS	ANCHORAGE	SHELTER HOLDING
Blacksod Bay	7-9 fath.	Harbor	Good
Inver Bay	10 "	Bay	"
Lough Swilly	6-9 "	Harbor	"
Strangeford	6-8 "	"	"

	Normal running Hours	Night coasting. Hours
Loading at New York	144	144
N.Y. to Liverpool 3073M. at 11 knots	279	
N.Y. to Blacksod, 2800M at 11 knots & 12hrs.		266
Blacksod to Liverpool 4 days		96
Unloading at Liverpool	144	144
Loading at Liverpool	24	24
Liverpool to Blacksod 4 days		96
Blacksod to N.Y. 2800M. at 9 knots & 12hrs.		323
Liverpool to N.Y. 3073M at 9 knots	341	
Unloading at New York	24	24
Totals	956	1117
Efficiency	100%	85.7%

Note; Reguler pilots travel on steamers when coasting.

168537°—20. No. 12. (See p. 167.)



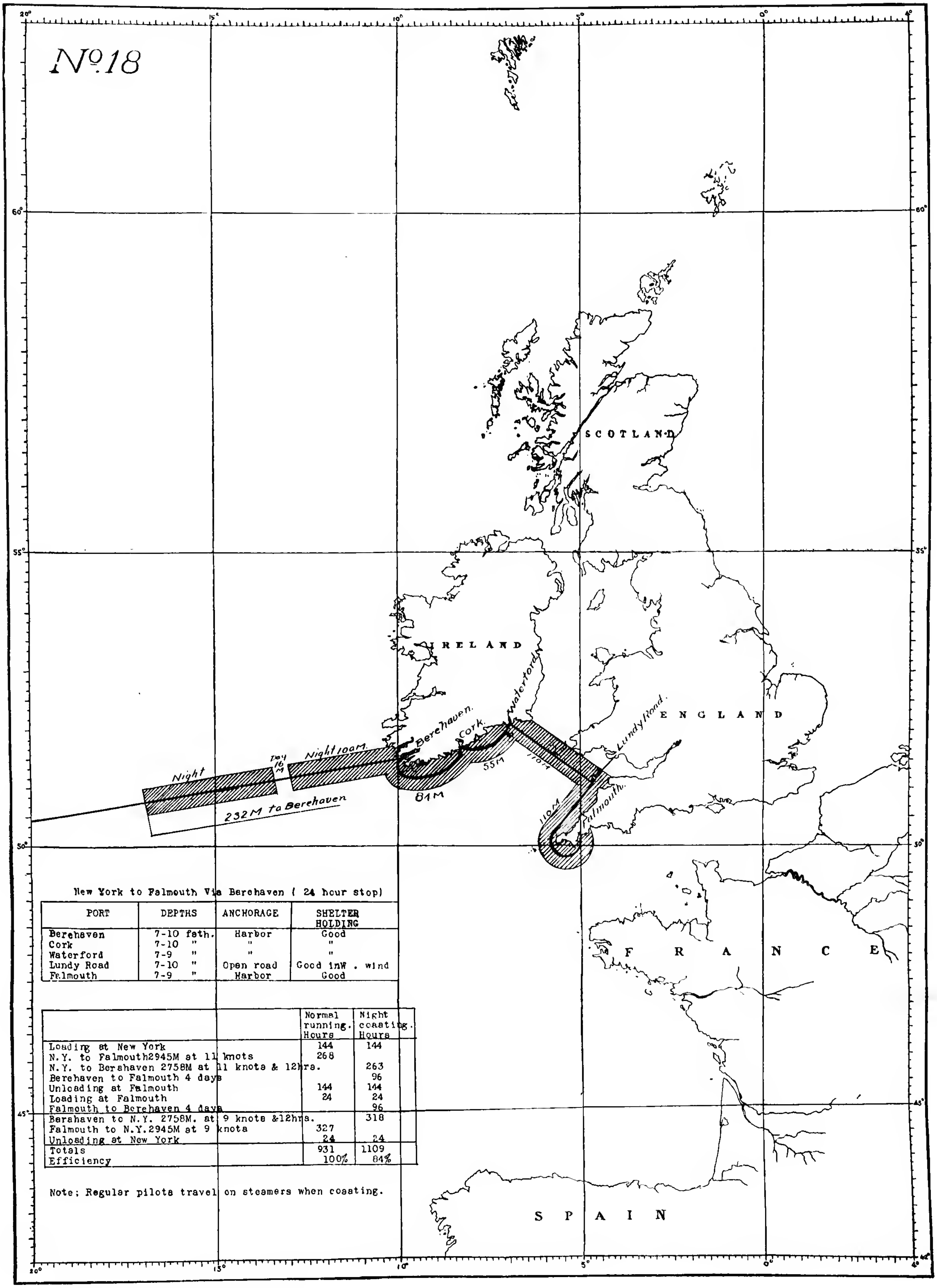
New York to Falmouth via Beresheven

PORT	DEPTHS	ANCHORAGE	SHELTER HOLDING
Bereheven	7-10 fath.	Harbor	Good
Cork	7-10 "	"	"
Waterford	7-9 "	"	"
Lundy Road	7-10 "	Open road	Good in W. wind
Falmouth	7-9 "	Herbor	Good

	Normal running. Houre	Night coasting. Houre
Loading at New York	144	144
N.Y. to Falmouth 2945M. at 11 knots	268	
N.Y. to Bereheven, 2758M. at 11 knots		251
Berehaven to Falmouth 4 days		96
Unloading at Falmouth	144	144
Loading at Falmouth	24	24
Falmouth to Berehaven 4 days		96
Bereheveh to N.Y.2758M at 9 knots		306
Falmouth to N.Y. 2945M. at 9 knots	327	
Unloading at New York	24	24
Totals	931-	1085
Efficiency	100%	85.8%

Note: Reguler pilots travel on steamers when coasting.

 (See p. 167.)



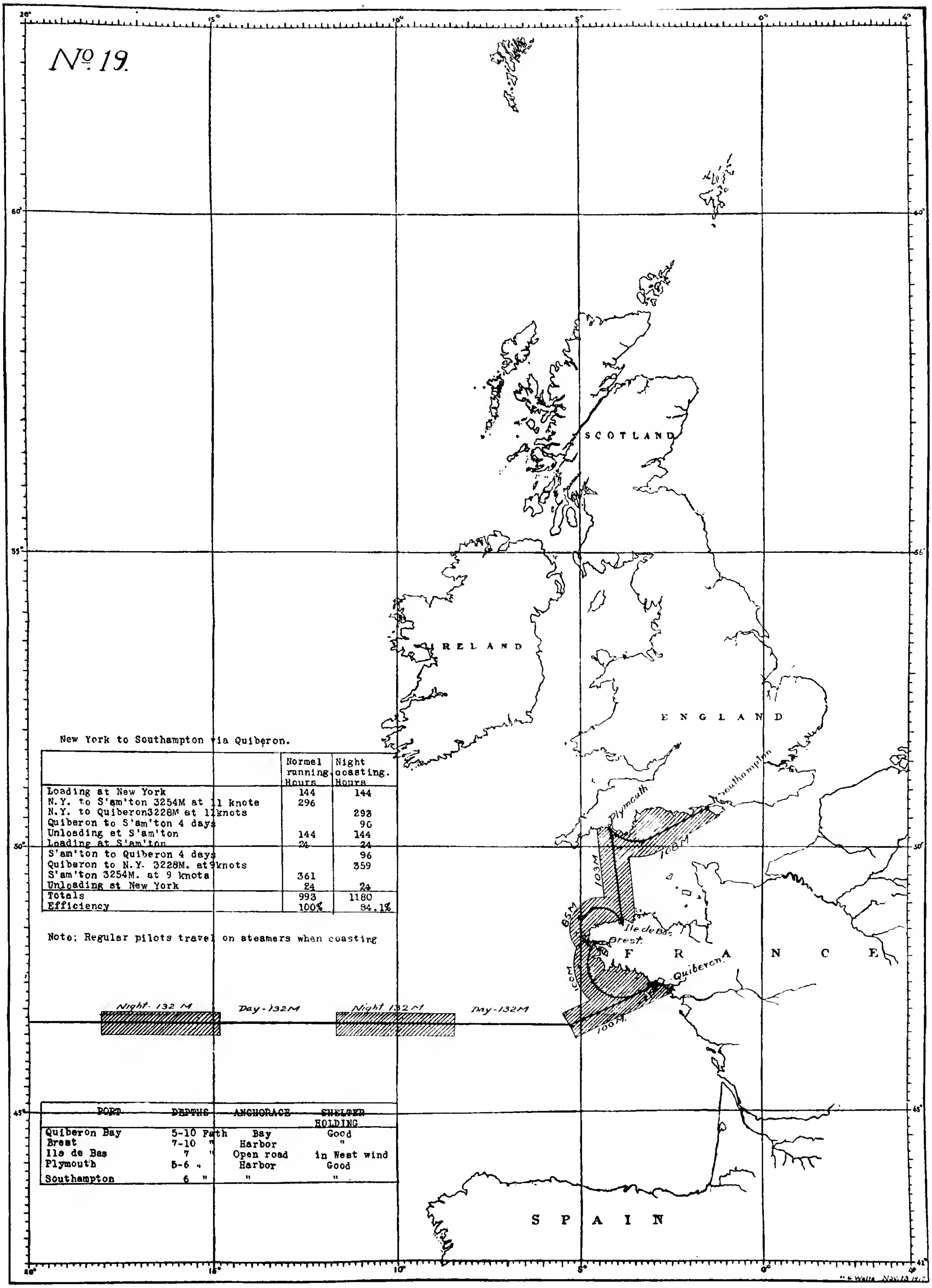
New York to Falmouth Via Berehaven (24 hour stop)

PORT	DEPTHS	ANCHORAGE	SHELTER HOLDING
Berehaven	7-10 fath.	Harbor	Good
Cork	7-10 "	"	"
Waterford	7-9 "	"	"
Lundy Road	7-10 "	Open road	Good inW . wind
Falmouth	7-9 "	Harbor	Good

	Normal running. Hours	Night coasting. Hours
Loading at New York	144	144
N.Y. to Falmouth2945M at 11 knots	268	
N.Y. to Berahaven 2758M at 11 knots & 12hrs.		263
Berehaven to Falmouth 4 days		96
Unloading at Falmouth	144	144
Loading at Falmouth	24	24
Falmouth to Berehaven 4 days		96
Berahaven to N.Y. 2758M. at 9 knots &12hrs.		318
Falmouth to N.Y.2945M at 9 knots	327	
Unloading at New York	24	24
Totals	931	1109
Efficiency	100%	84%

Note; Regular pilots travel on steamers when coasting.

168537°—20. No. 14. (See p. 167.)



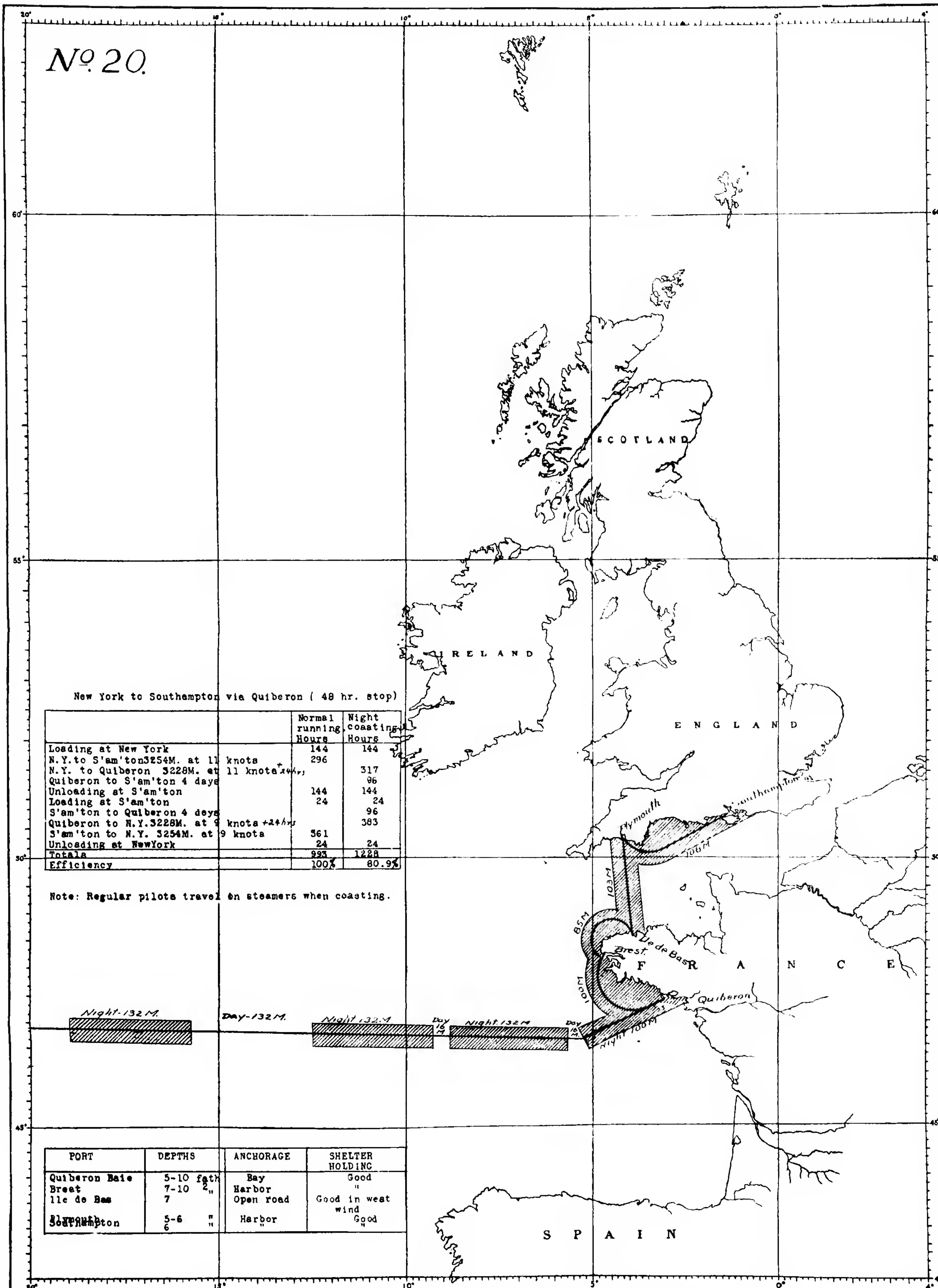
New York to Southampton via Quiberon.

	Normal running. Hours	Night coasting. Hours
Loading at New York	144	144
N.Y. to S'am'ton 3254M at 11 knots	296	
N.Y. to Quiberon 3228M at 11 knots		293
Quiberon to S'am'ton 4 days		96
Unloading at S'am'ton	144	144
Loading at S'am'ton	24	24
S'am'ton to Quiberon 4 days		96
Quiberon to N.Y. 3228M. at 9 knots		359
S'am'ton 3254M. at 9 knots	361	
Unloading at New York	24	24
Totals	993	1180
Efficiency	100%	84.1%

Note: Regular pilots travel on steamers when coasting

PORT	DEPTHS	ANCHORAGE	SHELTER HOLDING
Quiberon Bay	5-10 Fath	Bay	Good
Brest	7-10 "	Harbor	"
Ile de Bas	7 "	Open road	in West wind
Plymouth	5-6 "	Harbor	Good
Southampton	6 "	"	"

168537°—20. No. 15. (See p. 167.)



New York to Southampton via Quiberon (48 hr. stop)

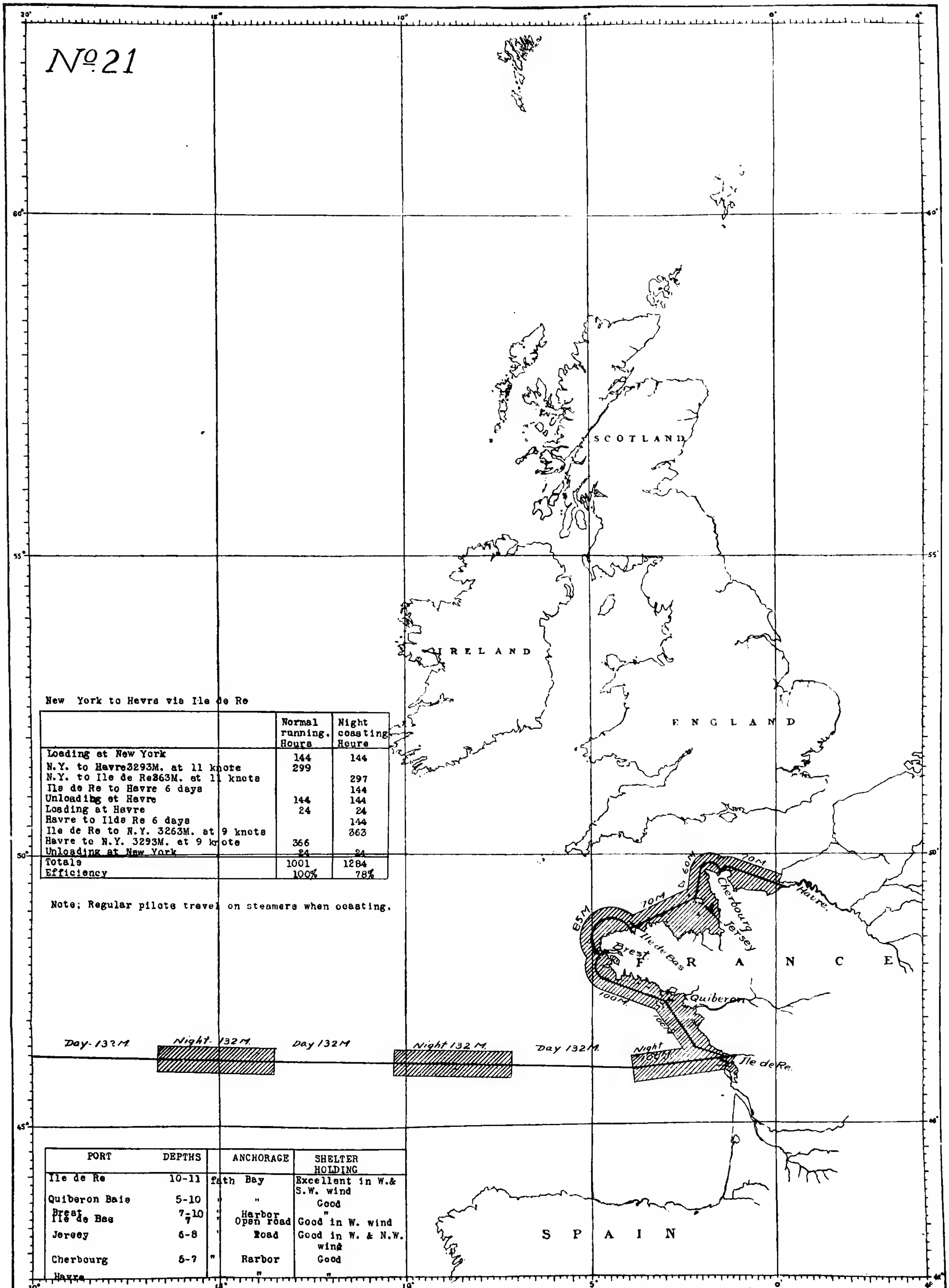
	Normal running Hours	Night coasting Hours
Loading at New York	144	144
N.Y.to S'am'ton3254M. at 11 knots	296	
N.Y. to Quiberon 3228M. at 11 knots +24 hrs		317
Quiberon to S'am'ton 4 days		96
Unloading at S'am'ton	144	144
Loading at S'am'ton	24	24
S'am'ton to Quiberon 4 days		96
Quiberon to N.Y.3228M. at 9 knots +24 hrs		383
S'am'ton to N.Y. 3254M. at 9 knots	361	
Unloading at NewYork	24	24
Totals	993	1228
Efficiency	100%	80.9%

Note: Regular pilots travel on steamers when coasting.

PORT	DEPTHS	ANCHORAGE	SHELTER HOLDING
Quiberon Baie	5-10 fath	Bay	Good
Brest	7-10 "	Harbor	"
Ile de Bas	7	Open road	Good in west wind
Plymouth	5-6 "	Harbor	Good
Southampton	6 "	"	"

N G Wells Nov 13 1917

No. 21



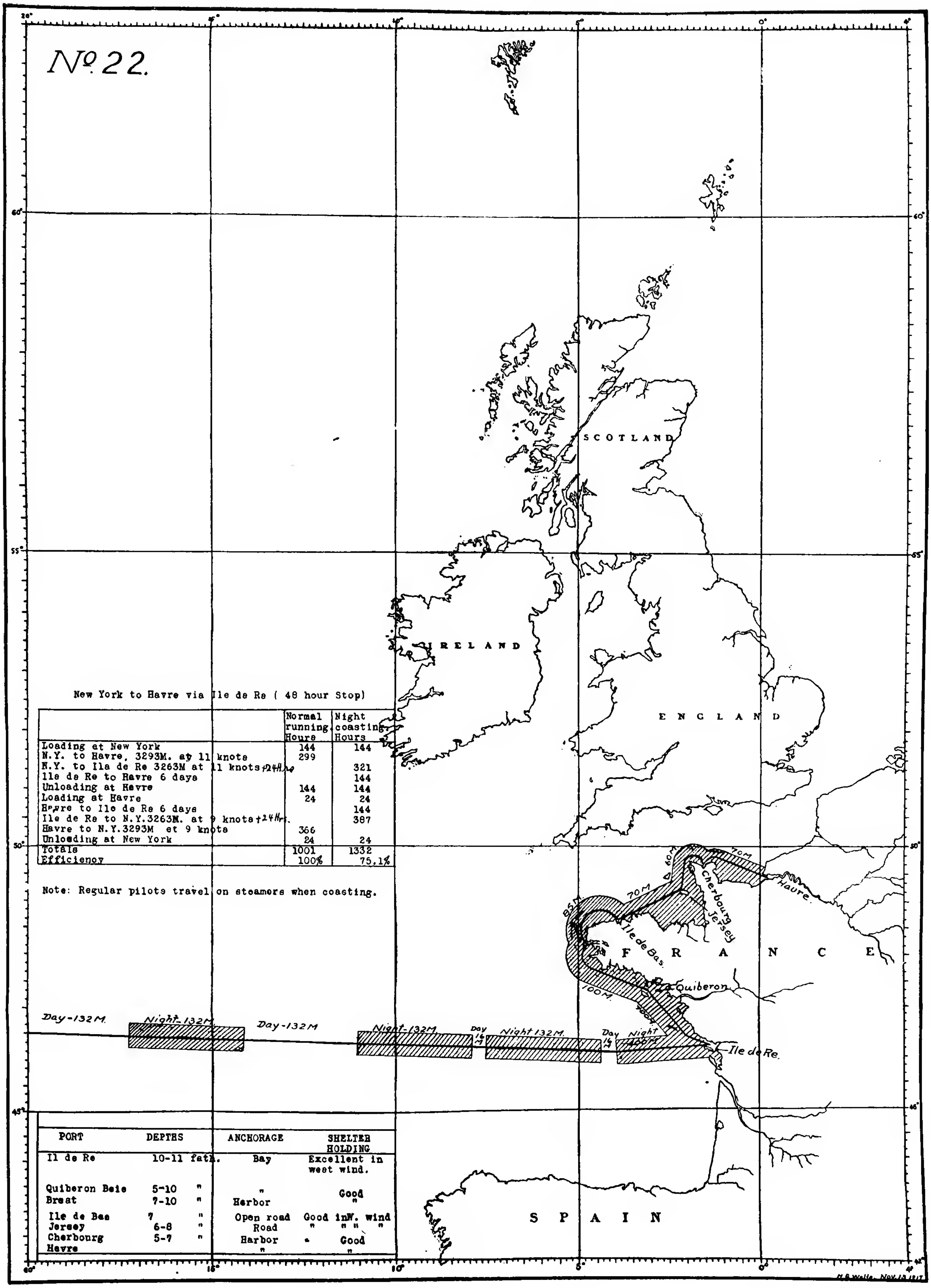
New York to Havre via Ile de Re

	Normal running. Hours	Night coasting Hours
Loading at New York	144	144
N.Y. to Havre 3293M. at 11 knots	299	
N.Y. to Ile de Re 3263M. at 11 knots		297
Ile de Re to Havre 6 days		144
Unloading at Havre	144	144
Loading at Havre	24	24
Havre to Ilde Re 6 days		144
Ile de Re to N.Y. 3263M. at 9 knots		363
Havre to N.Y. 3293M. at 9 knots	366	
Unloading at New York	24	24
Totals	1001	1284
Efficiency	100%	78%

Note; Regular pilots travel on steamers when coasting.

PORT	DEPTHS		ANCHORAGE	SHELTER HOLDING
Ile de Re	10-11	fath	Bay	Excellent in W.& S.W. wind
Quiberon Baie	5-10	"	"	Good
Brest	7-10	"	Harbor	"
Ile de Bec	7	"	Open road	Good in W. wind
Jersey	6-8	"	Road	Good in W. & N.W. wind
Cherbourg	6-7	"	Harbor	Good
Havre			"	"

168537°—20. No. 17. (See p. 167.)



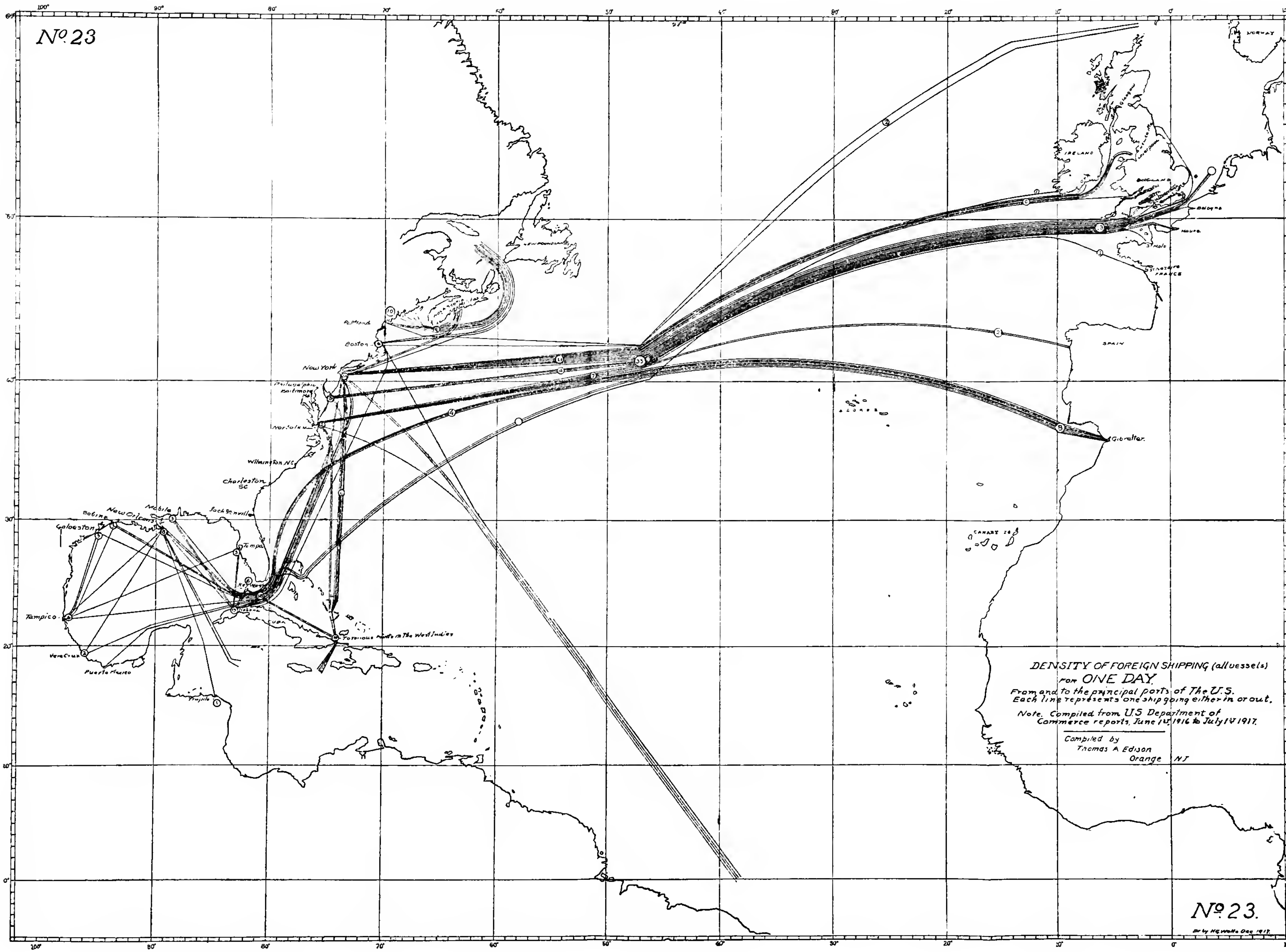
New York to Havre via Ile de Re (48 hour Stop)

	Normal running. Hours	Night coasting. Hours
Loading at New York	144	144
N.Y. to Havre, 3293M. at 11 knots	299	
N.Y. to Ila de Re 3263M at 11 knots +24Hrs		321
Ile de Re to Havre 6 days		144
Unloading at Havre	144	144
Loading at Havre	24	24
Havre to Ile de Re 6 days		144
Ile de Re to N.Y.3263M. at 9 knots +24Hrs.		387
Havre to N.Y.3293M at 9 knots	366	
Unloading at New York	24	24
Totals	1001	1332
Efficiency	100%	75.1%

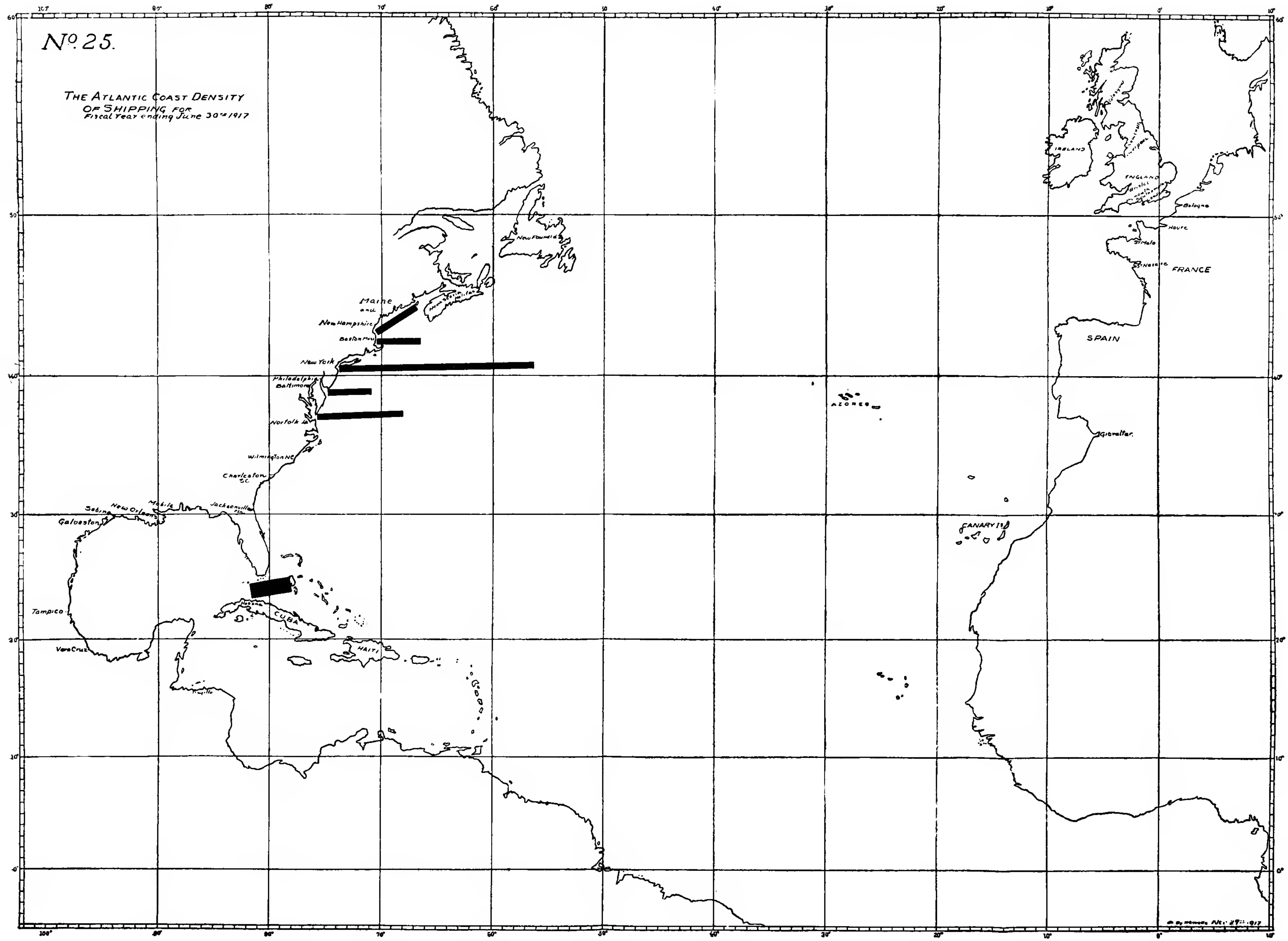
Note: Regular pilots travel on steamers when coasting.

PORT	DEPTHS	ANCHORAGE	SHELTER HOLDING
Il de Re	10-11 fath.	Bay	Excellent in west wind.
Quiberon Baie	5-10 "	"	Good
Brest	7-10 "	Harbor	"
Ile de Bas	7 "	Open road	Good in W. wind
Jersey	6-8 "	Road	" " " "
Cherbourg	5-7 "	Harbor	Good
Havre		"	"

168537°—20. No. 18. (See p. 167.)



168537°—20. No. 19. (See p. 167.)



168537°—20. No. 20. (See p. 167.)